



SCHOOL OF SCIENCE AND MATHEMATICS

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- **BIOLOGY** •
- **CHEMISTRY** •
- **EARTH SCIENCES** •
- **PHYSICS** •

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Note: The names of Millersville University faculty advisors are designated by an asterisk (*) in the abstracts.

Biology

1. What Lurks in the Shadows Beneath the Coquina Rocks? Biodiversity Knocks!

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There is a vast amount of life in the Matanzas River Basin; however an actual accounting of the biodiversity in this habitat has never been done. In order to assess the species diversity and richness in the estuary Drs. J. Núñez and M. J. Greenberg have begun an inventory of the organisms in the Matanzas River Basin. This is the first comprehensive analysis of the species found in this area. One component of this inventory was to assess the diversity of organisms within the microhabitat existing beneath the coquina rocks at the River to Sea Preserve. As a result of this study, close to 30 species were added to the existing inventory, at least 5 of which are invasive species. Over 24 species were found to live within the ectoproct *Anguinella palmata* hanging under the coquina rocks. A comprehensive understanding of species diversity and richness in this estuary is essential for future management and conservation.

Note: This project was completed as an independent study funded by an NSF Research Experiences for Undergraduates Internship at the Whitney Laboratory for Marine Bioscience.

2. Comparative genomic analysis of protein phosphatase 2C gene family in rice and Arabidopsis

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The protein phosphatase 2Cs (PP2Cs) have been implicated as regulators of various signal transduction pathways involved in diverse environmental stress responses and developmental processes. In this study, the family of PP2C genes in the two important model plant species, *Arabidopsis thaliana* (mouse-ear cress, a dicot) and *Oryza sativa* (rice, a monocot) were identified, classified into subfamilies, and compared. The expression patterns of the PP2Cs from rice and *Arabidopsis* and their upstream regulatory regions were analyzed and compared. Additionally, potential gene birth-and-death events as well as gene duplication events that likely contributed to the expansion of the PP2C family were traced. This comparative, genome-wide overview of the PP2Cs was the first attempt to provide a timely, complete overview of the PP2C gene family in *Arabidopsis* and rice. Importantly, this study provides insights into the functions and regulatory

mechanisms, as well as the evolution and divergence of the PP2C genes in dicots and monocots. Our results have established a solid foundation for future studies on the functional divergence in different PP2C subfamilies. Such understandings will ultimately lead to innovations in agricultural research enhancing the quality and quantity of agricultural production.

3. The Detection of Wild Game DNA in Maggot Tissue

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Our research involved the development of protocols and methodologies to determine if wild game DNA could be isolated and sequenced from carrion-feeding fly larvae at different stages of development. The analysis of insect tissue for the presence of animal/bird DNA may provide another technique useful in wild game management and conservation. Three species of carrion-feeding flies were reared on approximately 350 g of wild game liver (deer, bear, coyote). Maggots were collected mid-molt from each larval instar (1st, 2nd, 3rd instars), preserved and shipped to the Wildlife Forensic Laboratory for extraction and DNA sequencing. Maggot tissue sectioning and DNA extraction was performed using the MoBio Ultraclean Tissue Extraction Kit. Amplifications were performed using Promega PCR Master Mix. The success of the PCR reaction was determined using an agarose yield gel stained with ethidium bromide. Following the Post ExoSap, the PCR product was ready for DNA sequencing. Sequencing methods followed Big Dye v3.1 Qiagen DyEx Cleanup and AB 3130 protocols. Sequences were aligned and edited using Sequence Navigator software. We were successful in isolating DNA from all liver samples. Amongst all taxa tested, significantly more DNA was detected in *Calliphora vicina* larvae (ANOVA; F Stat = 7.37; P < 0.01). Developmental age of the maggot species tested did not affect the isolation and sequencing of wild game DNA. It appears that more DNA was detected in older (larger) *Lucilia cuprina* and *Sarcophaga haemorrhoidalis* larvae. We were able to isolate and sequence DNA from all three species of wild game and from all three fly species. We obtained a maximum identification score of 98% for the mitochondrial sequence examined in White-tailed deer. This study was the first to document the isolation and sequencing of wild game DNA from maggot tissue and demonstrate the potential in prosecuting wild game poaching cases in court.

4. A Simple Demonstration of Learning in *Paramecium caudatum*.

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Research using invertebrate model systems has yielded remarkable insight into the cellular mechanisms of learning and memory. The present study shows a learned response in a single-celled organism that lacks a nervous system.

Paramecium caudatum is a cigar-shaped, unicellular organism measuring about 250 µm in length that utilizes cilia for locomotion. Previous experimentation has shown that *P.*

caudatum is attracted to a mild cathodal stimulus. This study couples this phenomenon of cathodal attraction with differential lighting to demonstrate learning in small groups of paramecia.

A microscope concavity slide was fitted with stainless steel electrodes at opposite ends of the well. Approximately 20 paramecia were placed in the well in ~100 μ l of Sonnenborn's culture medium. During a three minute training session one half of the well was illuminated (3,150 lux) and the other half was shaded with black felt and an electrical stimulus was applied (6.5 V at 2 Hz). This was followed with a three minute resting session with uniform, reduced illumination (800 lux) and no electrical current. Finally, the paramecia were exposed to a three minute response session with the original differential illumination but without electrical current. About 500 individual paramecia (in groups of 15-20) were counted in the training, resting and response sessions. Chi Square analysis showed that during the training session the paramecia were attracted to the cathode without regard for the type of illumination ($p < 0.05$). During the resting session, there was no significant difference in the distribution ($p > 0.10$). In the response period, the paramecia moved to the light or dark area that was originally associated with the cathode during training ($p < 0.05$). Thus, these groups of paramecia demonstrated a learned response after a single training trial.

Current experiments are examining the duration of this memory and these results will be presented.

Chemistry

5. Progress Towards the Synthesis and Chemistry of Some 1,2-Diacyldiaziridines.

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The overall goal of this research is to investigate the bond-breaking selectivity of the three-membered diaziridine ring. To this end, we have been attempting to incorporate strain into the ring system by decreasing the ring size from six down to three in certain 1,2-diacyldiaziridines. In order to accomplish this, appropriate 1,1-dicarboxylic acids are converted into their acid chlorides which are then coupled with a specific 3,3-dialkyldiaziridine to produce the various 1,2-diacyldiaziridines needed for this study. The chemistry and reactivity of the diaziridines can subsequently be investigated in order to determine the effects of increased strain. The results of the progress of this investigation will be presented.

6. Coupling Receptor Targeting Ligands on Biodegradable Polymer Micro- and Nanoparticles

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Biodegradable polymer micro- and nanoparticles have found application as carriers and depository of drugs for controlled release. If suitably functionalized, the micro- and nanoparticles may also be used to deliver encapsulated drugs to specific tissue in order to minimize toxicity and improve efficacy. However, the commonly used polymers such as polylactic acid (PLA) and polyglycolic acid (PLGA) lack the high density reactive surface groups necessary for ligand conjugation. Layer by layer self assembly was used to introduce -NH₂ groups on the surface of PLA micro- and nanoparticles. Folic acid, a small ligand molecule that has a high binding affinity for the folate receptor was then covalently attached on the spherical particles. The ligand functionalized micro- and nano particles may be useful in delivery of drug to specific tissue based on folate-folate receptor binding. Characterization techniques used include transmission electron microscopy (TEM), fluorescence microscopy, UV/VIS and fluorescence spectroscopy and scanning electron microscopy (SEM).

Earth Sciences

7. Using HF Radar to Observe Coastal Ocean Tidal Features

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A long term coastal ocean observational network is being developed in order to improve our understanding of the dynamics of coastal environments. One aspect of this observing system is the deployment of High Frequency Radar (primarily CODAR) systems that can measure surface coastal ocean currents on hourly time scales up to 200 km offshore and at spatial resolutions of about 10 km. Tidal harmonics were computed using a year of observations from 3 CODAR systems deployed along the Delaware, Maryland, and Virginia coast under support from the NOAA Integrated Ocean Observing System (IOOS). The resulting tidal current estimates were then removed from the raw HF Radar current estimates to render a composite of the mean surface circulation pattern for this coastal ocean region. Tidal currents in this region account for up to 60% of the total current variability, particularly at the mouth of the Chesapeake Bay. Using the tidal harmonics, a year's worth of daily progressive vector diagrams were analyzed in order to ascertain the level of 'jitter' that one could expect from obtaining hourly images from a geostationary hyperspectral ocean color satellite such as NASA's GEO-CAPE mission.

8. A simple technique to remove tidal influence from ADCP measurements

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Acoustic Doppler Current Profiler (ADCP) measured current velocities close to the coast are strongly influenced by the local tides. In this study, we demonstrate a new simple technique that allows us to de-tide the observed ADCP velocities. The technique is based on simple vector differencing. The first step in the process is to produce tidal velocities of the region using the ROMS model. In the next step, we remove the tidal velocities from the ADCP data using vector differencing at a number of points along the ships track. An extensive error analysis will be carried out to assess the validity of our de-tiding methods. Two sets of points will be used in this study. The first set will contain points that lie inside the model domain and the second set of points that lie on the model boundary. In this way, we can determine the effect of the model boundaries on the above technique. Results will determine the feasibility and accuracy of the technique.

9. Earth, Wind, Sea, and Sky

Jones, McArthur, Jr.; Liu, Han-Li; Richmond, Arthur; Jones, Jamaica; McInerney, Joe

Through perturbation interactions with the zonal mean flow, the migrating diurnal tide and the diurnal eastward 3 (DE3) tide are fundamental to a holistic understanding of the atmospheric dynamics at mesosphere lower thermosphere (MLT) and low ionospheric altitudes. Previous tidal studies have noted the semiannual variability associated with the migrating diurnal tide and the DE3 tide, which maximize around equinox and minimize around solstice. Seasonally varying source and dissipation regions and/or wind structures are believed to cause the differences in the maximum amplitudes experienced between the two equinoxes. Utilizing monthly averaged output from the Whole Atmosphere Community Climate Model-Extended (WACCM-X), this study is among the first to apply this model to a diagnostic examination of the sources and sinks of tidal momentum and document the associated seasonal variability. From the averaged amplitudes obtained during March and September, the WACCM-X replicates the observed seasonal variability associated with the migrating diurnal tide and the DE3 tide. Calculating the divergence of the Eliassen-Palm Flux (EP Flux) for the migrating diurnal tide revealed robust seasonal variation which may be linked to differential solar heating of ozone in the stratosphere. Seasonal variation in the tropospheric sources of the DE3 tidal momentum alone does not appear to explain the semiannual variability observed in the tidal amplitudes. This study provides a better understanding of the seasonal variation in the generation and dissipation mechanisms of the migrating diurnal tide and the DE3 tide.

10. A Comparison of Different Green Roof Constructions on Runoff Nitrate Fluxes

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The Green Roof Project is of environmental significance because it helps to improve the overall quality of our water. Green roofs reduce nitrates (NO_3^-) counteracting

eutrophication in surface waters. In addition, by using green roof media on rooftops across the Susquehanna Valley, we can neutralize the pH and reduce the volume of rainwater runoff. To measure the benefits of green roof media, we set up three plots, the first reflecting standard roof construction, the second containing only green roof media, and the third containing the green roof media as well as a lining of recycled fabrics and drainage conduit. Using the standard EPA method for measuring nitrates in a sample of runoff from the three plots, we find that nitrate levels were reduced from 0.160 mg/day in plot 1 to 0.057 mg/day in plot 2 and 0.078 in plot 3. Other findings include a more neutral pH of 6.85 in plot 2 and a pH of 6.73 in plot 3 as opposed to the average pH of rainwater in plot 1 of 5.3. The green roof media in plots 2 and 3 also reduced the total rainwater runoff from 1445.45 mL/day to 898.59 mL/day in plot 2 and 1015.58 mL/day in plot 3. Although this project is ongoing, the results thus far seem to verify the many benefits to having green roofs. The nitrate flux decline shows that eutrophication in surface waters can be reduced by the use of green roofs. The findings of a pH of 5.3 in the Susquehanna Valley may be harmful to the region's wildlife and waterways if not neutralized by an effort such as green roofs. The reduction in rain water volume also leads us to believe that flooding in urban areas can be minimized by the use of green roofs.

Physics

11. Self-Assembled Monolayer Structures of Polystyrene Spheres

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The production of self-assembled monolayer structures of polystyrene spheres is investigated in this project. Monolayers of polystyrene spheres can be produced with an apparatus that will vertically extract a glass slide from a solution containing the particles. The extraction rate must match the evaporation rate of the solution to ensure that the particles will assemble automatically as they are pushed together via the water tension. Producing these slides could later allow for surface plasmon resonance observations to be made with a discontinuous thin metal layer to be deposited later.

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