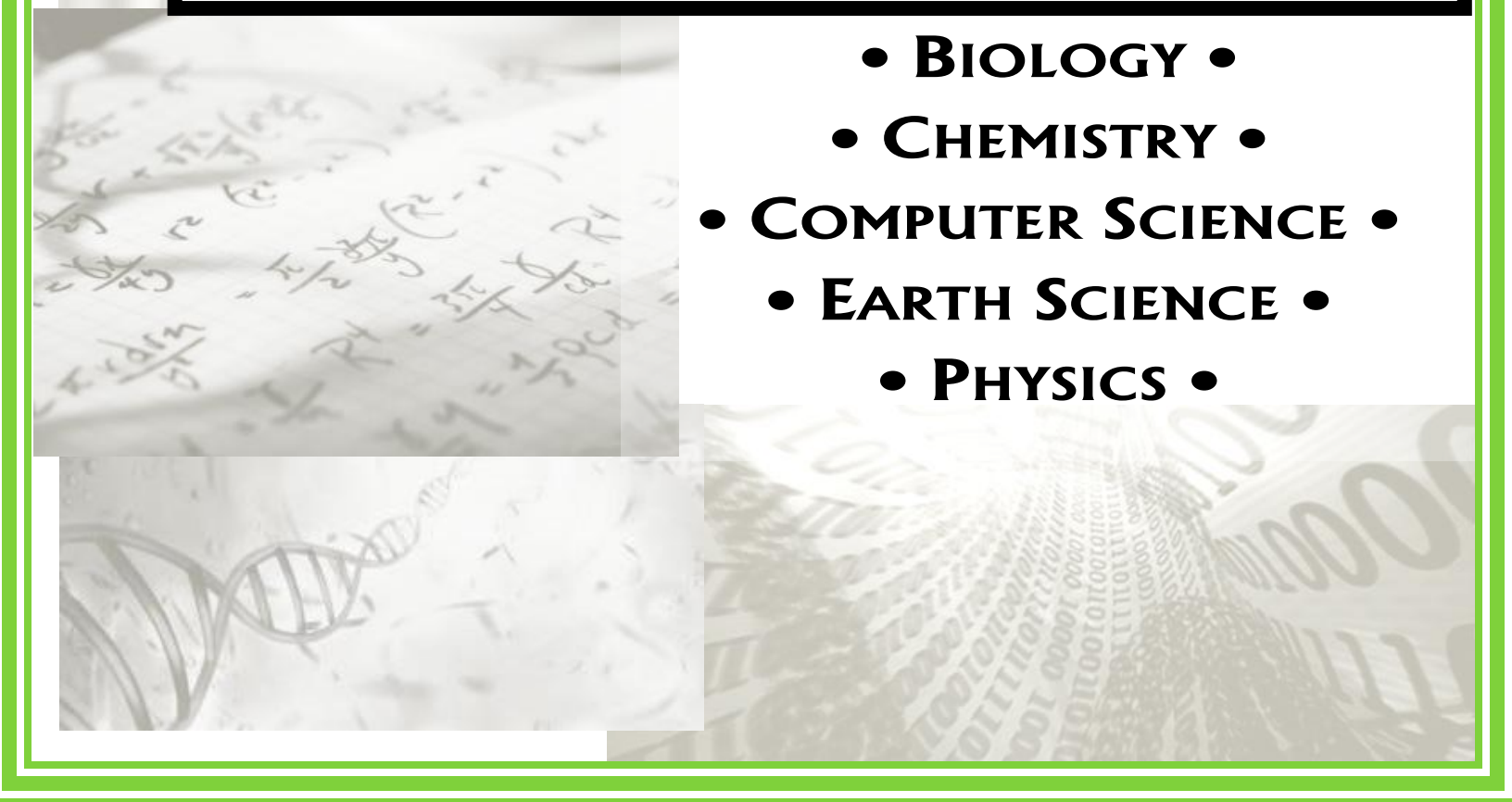SCHOOL OF SCIENCE AND MATHEMATICS

Student Research Poster Display

April 21-28, 2010 Caputo Hall Lobby

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

Biology

1.   Pelagic Tunicates: Seasonal and Depth Distributions off the Coast of Wallops Island, Virginia

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Pelagic tunicates are holoplanktonic zooplankton, which pose a potentially high impact on phytoplankton abundance due to their non-specific grazing habits. At five stations along a 30 km transect, three types of pelagic tunicates were observed: salps, dolioilds, and appendicularians. Samples were collected using .5m x .5m Tucker trawls and .3m diameter vertical tows with 80um mesh. Tunicates were found in highest densities below the thermocline, where phytoplankton concentrations were highest. *Dolioletta gegenbauri*, the dominant doliolid species, was observed primarily from late August through early October in 2006 and 2007, with concentrations as high as 8,8000 organisms m^{-3} at the offshore stations. The appendicularians, *Oikopleura dioica* and *Appendicularia sicula*, were observed in relatively high abundance from early June through late October in 2006 and 2007, with highest concentrations nearshore: 15,480 organisms m^{-3}. One species of salp, *Thalia democratica*, found in high concentrations only in late July was abundant both above and below the thermocline. Although high abundances of pelagic tunicates, primarily doliolid species, have been well documented for the South Atlantic Bight, our study is the first to document the nature of these assemblages in the southern Mid-Atlantic Bight.

2.   The Role of Meadow Voles in Sapling Survival During Riparian Forest Restoration

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High mortality of tree saplings in riparian forest restoration frequently is attributed to the behavior of meadow voles. We investigated this relationship via a series of field and lab experiments. Manipulation of vegetation height in grass-dominated meadow revealed that vegetation height <30 cm (≈10,575 lux) produced significantly fewer live trap captures of meadow voles than vegetation >45 cm (<4300 lux). In a series of behavioral choice experiments, naïve, adult voles spent significantly more time in the darkest chambers (≤ 2000 lux). Adding food to the chambers with the highest intensity light (14,000 lux), failed to change the preference of naïve voles for the darkest chambers. In other experiments involving food, naïve adults also consumed more food in the darkest chambers. When given a choice among four food items, adult voles, food deprived for 2 hr, demonstrated significant preferences for a) stems of green ash over those of river birch, white oak, and sweet gum, b) brome and orchard grass over sweet gum and green ash, and c) creeping thistle, brome, and orchard grass over green ash. Our findings support the traditional position that woody tissue many be a secondary food source for meadow voles, consumed only when preferred herbaceous foods are in short supply.

3.   Spatial and Temporal Distribution of *Hydra (Chlorohydra) viridissima*

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Freshwater hydra are cosmopolitan in their distribution with multiple species found in Pennsylvania. Hydra have no medusa or free swimming larval form that might enhance their distribution, yet it seems that they are able to distribute and colonize their habitats with ease. This study focuses on the spatial and temporal distribution of *Hydra* (*Chlorohydra*) *viridissima* in a small pond in Lancaster County, PA. Although known methods of dispersal for green hydra include gas bubble flotation and the somersault method, it is unknown how far these organisms can travel and what environmental factors influence colonization. Monitoring stations containing vertically tiered settling plates (3 x 85 cm diameter Petri plates per depth) were placed at three locations in the Roddy research pond, a small freshwater pond (0.2 ha) located at Millersville University. This research pond is teardrop shaped and is bordered by *Phragmites* and cattail vegetation. The narrow end of the pond, known as the **apex**, is shallow (~ 1 m) and contains extensive infralittoral vegetation made up of *Nitella* and *Phragmites* rhizomes. The **mid-pond** region is a deeper pelagic area (~ 4.5 m depth) with very little vegetation. Finally, the **base** of the teardrop has a moderate depth (~ 2 m) and lacks benthic vegetation. Sampling was conducted during two separate time periods (August - October 2009) and November 2009 - March 2010). Hydra colonized the shallow end of the pond in preference for other regions regardless of season (**apex:mid-pond:base**, winter 13:0:1, summer 8:0:1). We also found similar changes in population density during both sampling periods (~ 60 hydra/week). In the apex samples, hydra were present on the benthic plates in preference to those at surface (Wilcoxon's ranked sign test $p<0.02$). Colonization of hydra on the upper side as compared to underside of plates was the same in the winter, however there was a preference for the underside in the summer. This seems to show that green hydra will colonize in areas that provide optimal forging as opposed to optimal photosynthesis.

4.   The Identification and Expression Analysis of the Terpene Synthase Gene Family in Glandular Trichome-bearing Medicago and Non-Glandular Trichome-bearing Arabidopsis

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A genome-wide analysis and comparison of the terpene synthase (TPS) gene family has been conducted in two model species *Medicago truncatula* and *Arabidopsis thaliana*. TPS synthesizes a class of important natural products called terpenes (i.e. terpenoids), which are used extensively in the manufacture of medicines, pesticides, perfumes and essential oils. *Arabidopsis* and *Medicago* represent two types of trichome (i.e. hair)-bearing plants. *Medicago* has both glandular and non-glandular trichomes, whereas *Arabidopsis* has only non-glandular trichomes. A comprehensive computational analysis has identified 121 and 84 TPS genes in *Medicago* and *Arabidopsis*, respectively, which denotes the TPS gene family as one of the largest gene families identified in plants. Expression pattern analysis suggests that

1) there are much more TPS genes in *Medicago*, which bares both types of trichomes, than in *Arabidopsis* which bares only non-glandular trichomes, 2) the TPS genes in *Medicago* have much more tissue-specific expression that those in *Arabidopsis*, and 3) the two types of trichomes appear to be under both shared and different gene regulation. These results and our forthcoming research will provide novel insights into the function of the TPS gene family members and the role of glandular trichomes in terpene biosynthesis, and will lead to innovations in biomedical/agricultural research enhancing product quality and quantity by manipulating the production of terpenes only in glandular trichomes, leading to increased disease resistance and enhanced environmental protection, and improved safety of transgenic crops.

5.   Learning and Memory Retention in *Paramecium caudatum*
Smith, J.M.; Reinking, Larry*
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Invertebrate model systems have yielded remarkable insight into the cellular mechanisms of learning and memory. The present study not only demonstrates a learned response in groups of singled celled organism, but also demonstrates retention of the learned response. *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 the phenomenon of cathodal attraction with differential lighting to demonstrate learning in small groups of paramecia. Additionally, extinction trials were run to determine the retention time of the learned brightness discrimination.

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 μl of Sonnenborn's culture medium. During a three minute training session one half of the well was illuminated (3,150 lux) and the other was shaded with black felt and an electrical stimulus was applied (6.5 V at 2 Hz). Next, the paramecia were exposed to 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.

Chi Square analysis (df=1) showed that during the training session paramecia were attracted to the cathode without regard for the type of illumination ($p < 0.05$). During the resting session, no significant difference in distribution was observed ($p > 0.10$). In the response period, paramecia moved to the light or dark area that was originally associated with the cathode during training ($p < 0.05$). A reversal experiment showed that paramecia responded to the lighting regime rather than the physical positioning of the overhead light ($p < 0.05$). Thus, these groups of paramecia not only demonstrated a learned response after a single training trial, they demonstrated the ability to retain the learned response.

To determine memory extinction, additional resting and response periods were run following the initial three minute response session. Chi square analysis showed that the learned response lasted twelve minutes.

6.   Can Cuttlefish Break Camouflage for a Food Reward?

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Many invertebrate species' defense behaviors do not involve learning. Cephalopods have the largest and most complex brains of any of the invertebrates and also show excellent camouflaged body patterning. Can they be conditioned to change their body pattern for a food reward? Cuttlefish were placed in a tank, either all white or all black, and allowed to acclimate. Once acclimated, their body pattern matched the tank. Next, a contrasting probe of the opposite color (black or white) was inserted into the tank. If the cuttlefish then changed its body pattern to contrast with the tank, a live ghost shrimp was delivered through a feeding tube. Trials were recorded using a video camera. Latency to body pattern change and a description of the body patterns expressed were noted. Each cuttlefish received 3 trials per day for 15 days. Latency to contrasting body pattern did not decrease; however, there was a small increase in the degree of contrast in body patterning expressed. Results suggest that an experiment of longer duration might yield stronger evidence of conditioned learning.

CHEMISTRY

7.   Development of an Analytical Chemistry Experiment Involving Surface Enhancement of Raman Spectroscopy Using Silver Nanoparticles

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This project involves the development of a new experiment incorporating nanotechnology and Raman spectroscopy for a chemical instrumentation course. The sample being measured is diluted in aliquots until the Raman spectrum displays only a slight peak. Then using silver nanoparticles obtained by citrate reduction, the spectrum was enhanced. This enhancement of the Raman spectrum is known as Surface Enhanced Raman spectroscopy (SERS). The experiment allows students to observe spectra of successively more dilute solutions and then to see the effect of adding silver nanoparticles to enhance the spectra. Signal to noise ratios and detection limits will be determined for spectra obtained with and without the silver nanoparticles. Spectra of several common organic substances will be investigated. Data analysis will include assignment of prominent absorption frequencies to vibration modes within the compound.

8.   Diaziridines: Progress Towards the Synthesis of Some 2-Sulfobenzoyl-, and 1,2-Dibenzenesulfonyldiaziridines

Shahan, Shaun; Bonser, Steven*
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Diaziridines are a class of three-membered ring heterocycles that contain one carbon and two nitrogen atoms. They are useful intermediates in the synthesis of more complex heterocyclic compounds, some of which have found applications in the pharmaceutical industry. Although several studies on the synthesis and chemistry of 1-aroyl-, and 1,2-diaroyldiaziridines have appeared in the chemical literature, there are no reports on the synthesis and chemistry of their *dibenzenesulfonyl*, or their *2-sulfobenzoyl* analogues. Thus, we are attempting to synthesize a variety of these diaziridine derivatives in order to study their chemical reactivity. It is anticipated that this project will shed some light on how different electron withdrawing groups influence the reactivity of the three-membered diaziridine ring. The results of the progress of this investigation are the subject of this poster.

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

Smith, Joshua B.; Mbindyo, Jeremiah*
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Biodegradable polymer micro- and nanoparticles have found application as carriers 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, 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 $-NH_2$ 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 drugs to specific tissue based on folate-folate receptor binding.

10.   Synthesis and Characterization of Imidazole Based Carbene Iridium (I) Complexes

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N-heterocyclic carbenes have sometimes been considered alternatives to phosphines as spectator ligands in homogeneous catalysis, and share with them the possibility of tuning catalyst activity by varying the substitution scheme of the ligand. The imidizole carbenes have been relatively little studied thus far, but are very promising ligands for catalytic applications. A series of new imidazole based carbene iridium (I) complexes was synthesized and characterized using multinuclear NMR, X-Ray diffraction, and elemental analysis. Their catalytic activity will be studied in organic synthesis, especially in transfer hydrogenation reactions.

COMPUTER SCIENCE

11.   Improving User Experience Through Ubiquitous Computing

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The Easton Area School District maintains a portion of the district's website dedicated to keeping students, teachers, and faculty informed of the latest news. This project utilizes the iPhone Software Development Kit to create an application with the ability to update the district's website remotely, from any iPhone. As long as the phone has a cellular connection, site administrators can browse news events and perform basic content management functions, such as editing, deleting, adding, and reordering events. This greatly improves the administrators' ability to keep the site up-to-date, thus improving the end users' experience as well.

12.   Geopod: A Virtual Platform for Immersive Data Visualization

Waegel, Ky; Root, Michael R.; Mitton, Kenneth T.; Zoppetti, Gary*; Yalda, Sepideh*; Clark, Richard*
Department of Computer Science, Millersville University, Millersville, PA 17551

The Integrated Data Viewer (IDV) is a popular data visualization tool for students in the geosciences. Visualizations of 3-D real-time atmospheric data, including gridded output from weather models, are commonplace in the meteorology community. Although IDV allows students to view 3D datasets, they cannot "step into" the dataset for a more immersive experience; they are restricted to viewing the atmosphere from *outside* the data volume. Furthermore, the interface is cluttered and unintuitive. We are developing **Geopod**, a novel extension to IDV that will allow students to immerse themselves and to navigate within real and current data while being guided by a tiered instructional design strategy. The investigators envision that this will lead to enhanced learning and discovery.
Geopod currently features an intuitive, easily navigable interface that is designed to facilitate learning and exploration. Our interface presents a view synchronized with IDV's display window, giving students increased flexibility and the ability to seamlessly switch between both. We have designed this interface, in collaboration with a graphics artist, using our own library of classes that extend the Java 3D framework. This library allows us to display arbitrary widgets in three-space that remain aligned with the virtual camera. We have also developed routines to translate the Geopod *into* the 3D volume, while maintaining a flight-simulator-like perspective. To enable smooth navigation we have implemented a multi-threaded update system that buffers movement commands, continuously samples data, and renders relevant parameters to a display area.
Future work includes refining our mission framework. This framework will allow an instructor to design a lesson plan in the form of an exploratory mission with defined objectives, learning outcomes, and assessments to track and measure progress.

EARTH SCIENCES

13.   Facilitating Tropical Cyclone Analysis of Hurricane Satellite (HURSAT) Imagery with Google Earth

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[1]NOAA, NCDC, Asheville, NC 28801

Tropical cyclone satellite imagery can be used for various applications. Some examples include reanalyzing storm intensity, improving forecast techniques, and training analysts. The Hurricane Satellite (HURSAT) dataset was used to create more than one million satellite images for worldwide tropical cyclones. The imagery derive from infrared, visible and microwave data. Imagery were created using similar color scales as the widely used Navy Research Laboratory (NRL) satellite tropical imagery. Google Earth facilitates the browsing and comparison of all these imagery. The National Climatic Data Center (NCDC) now hosts all imagery online and serves them via Google Earth, which is a freely available data display system. The Keyhole Markup Language (KML) file design allows for simple access to millions of images for more than two thousand tropical cyclones in just a few clicks.

14.   Using HF Radar to Observe Coastal Ocean Tidal Features

Davies, Alexander R.; Moisan, John[1]; Kumar, Ajoy*
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[1]NASA

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.

15.   Correlation Between Vehicle Miles Driven and Air Quality in Select U.S. Cities

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In recent years, the United States has experienced an increase in gas prices and a consequent decrease in vehicle miles driven when gas prices rise above $4.00/gallon. From January through September 2008, Americans drove 79 billion, or 3.5 percent, fewer miles as compared to the same period in 2007. We developed the hypothesis that a reduction in

vehicle miles of this magnitude will correlate with improved surface air quality? Ozone and PM2.5 levels are examined in both years to determine if there is a direct correlation between the miles traveled and observed concentrations of those pollutants. Meteorological fields are investigated to attempt to understand the differences in pollutant concentration due to weather influences. This poster reports on the methods of data reduction and analysis with an emphasis on understanding whether the differences in miles driven and the attending reduction in emissions of ozone precursors and particulate matter result in an observed decrease in pollution as measured by state criteria gas monitoring networks, or if the signature is masked by differences in the weather patterns between 2007 and 2008. Results indicate that weather conditions between the two years completely overwhelmed our ability to detect a statistically significant change in air quality.

**16.   De-Tiding of ADCP Velocities Collected Over the Continental Shelf and Shelf
          Break Region off the Delmarva Peninsula Using the ROMS Model**

Gilchrist, Justin; Davies, Alexander R.; Kumar, Ajoy*
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This research looks explore a new method of de-tiding hull mounted Acoustic Doppler Current Profiler utilizing ROMS model output data. Derived current vectors from ROMS are de-tided using harmonic analysis. A vector differencing method is employed to estimate the de-tided current velocities where ADCP data was available. Resultant current velocities represent shelf currents with the tidal components removed. An extensive error analysis will be carried out to assess the validity of our de-tiding methods.
This is employed to assist in the explanation of the origin of the nutrient depleted waters that plaque the entrance of the Chesapeake Bay. To further supplement our results, CDT and estimated upwelling indexes will be used to help verify the both the existence and the migration of this nutrient depleted water across the shelf.

17.   Improving Atlantic Hurricane Predictions with the Madden-Julian Oscillation

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[1]Department of Atmospheric Science, Colorado State University, Fort Collins, CO 80523

The Madden-Julian oscillation (MJO) has been shown to have a pronounced impact on Atlantic hurricanes. The MJO is a pattern of tropical winds and precipitation that repeats every 30-60 days. In addition, the MJO has 8 phases and spends about 6 days in each phase. Studies have found that the oscillation, which travels eastward from Asia to Africa, modulates Atlantic hurricanes. This information might be used to predict Atlantic hurricane activity a few weeks in advance. The objective of this research is to find a way to improve the prediction of Atlantic hurricanes with the MJO for better preparedness and preparation. This research project was comprised of taking HURDAT data and MJO indices to find comparisons. The years of study used in this research were from 1974 to 2008. The first step was to make a time series plot similar to that in Wheeler and Hendon's article of the phases of the MJO. After doing so, plots were created to show the genesis locations of the storms in each of the phases of the MJO. Comparisons and contrasted were then developed to find a relationship between the MJO and the Atlantic hurricanes. Further studies must be done to

find the effects of the MJO, El Niño and seasonal cycle on hurricane activity to better make hurricane activity forecast.

18. A Case Study of the 13-14 February 2007 Extended Sleet Event

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A major winter storm affected much of the Mid-Atlantic and Northeastern United States on 13-14 February 2007. For an extended and nearly uninterrupted period of 15 hours between approximately 23 UTC 13 FEB and 16 UTC 14 FEB, precipitation in the form of sleet (ice pellets) fell over much of south central Pennsylvania, northern Maryland, and parts of New Jersey. This research investigated the factors contributing to this unusually long precipitation event. The influence of a persistent easterly low-level jet, which helped to maintain a consistent pool of cold air in the near-surface layer, was an important factor in maintaining precipitation in the form of sleet. Temperature and humidity profiles from the NAM, RUC, and GFS were analyzed to determine the mechanism by which this extended sleet was sustained. Bourgouin's method of determining precipitation types was implemented in the model soundings to show that sleet was favorable during the times of interest.

19. 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 nitrate (NO_3^-) concentrations, thereby counteracting eutrophication in surface waters. By using green roof media on rooftops across the Susquehanna Valley, rainwater runoff pH can be neutralized and volume reduced. 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 nitrate concentration , we find that nitrate levels were reduced from 0.39 mg/day in plot 1 to 0.032 mg/day in plot 2 and 0.040 in plot 3. Other findings include a more neutral pH of 6.86 in plot 2 and a pH of 6.64 in plot 3 as opposed to the average pH of rainwater in plot 1 of 5.51. The green roof media in plots 2 and 3 also reduced the total rainwater runoff from 1.0 L/day to 0.78 L/day in plot 2 and .80 L/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 5.51 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 runoff volume also leads us to believe that flooding in urban areas can be minimized by the use of green roofs.

20.   An Investigation of Severe Climatology of the Chesapeake Bay Region

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The Chesapeake Bay region is characterized by the Appalachian Mountains to the west, the Atlantic Ocean to the east, and various land-use patterns (e.g., forested areas, agriculture zones, and urbanized centers). Moreover, the Chesapeake Bay itself possesses a highly convoluted coastline. It has been speculated that this complex geography is a factor in the corresponding spatial variability of severe convection. The present research uses 48 years of severe storm data (wind, hail, and tornado events) to first establish a regional climatology of severe convection. The results of this component of the study reveal that the number of reported severe weather events has increased significantly from around 200 events in 1960 to almost 15,000 events in 2008. In order to resolve whether this increase is real or biased by some other factors such as population and/or storm detection technology, we used Census data and information on the development of storm detection radar. These results suggest that the observed increase in storm frequency is strongly affected by advances in storm detection technology such as Doppler radar capability, but also as a consequence of the increase in storm observers who were trained to provide validation for the expansion of the network of new WSR-88D Doppler weather radar that were installed from the mid-1980s through 1995. Not only have spotters been responsible for the increased number of reports of severe weather made to the National Weather Service, but enhancements in technology are able to detect severe weather events in locations and at times that might be missed by the spotters and general public. With the common use of digital cameras, cell phones, and the internet the public can report storms quickly and easily. With 16.6 million people living in the Chesapeake Bay Watershed as of 2007, the effect of these severe convective storms has an impact on increasing numbers of lives and property.

Physics

21.   Supernova Remnants in the Large Magellanic Cloud

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Supernovae represent the last stage of stellar evolution when certain types of stars detonate. Supernova explosions are categorized by the spectral profile of the expanding shockwave, and are separated into Type I and Type II supernovae, based on the absence or presence of hydrogen, respectively. This distinction arises from the explosive origins of the star -- Type Ia supernovae occur when white dwarf stars exceed the Chandrasekhar limit of 1.44 Solar masses and thermonuclearly detonates, while Type II supernovae the result of the gravitational collapse of a massive star. Both of these types of explosions create and disperse the heavier elements. All supernova remnants follow a similar progression, from the initial ejecta-dominated phase, where the mass expelled by the star outweighs the swept-up interstellar medium, into the Sedov-Taylor phase, where the SNR has swept up a significant amount of ISM, and finally into the snow-plow phase, where the shock front has cooled and recombination between heavier nuclei and free electrons begins. The Large Magellanic Cloud provides a variety of supernova remnants at various stages at a uniform distance. This project examines X-ray emission from three remnants: 0453-68.5, N49, and N49B. Data from the Chandra X-ray Observatory was analyzed with the CIAO data analysis package and the XPSEC spectral fitting software. N49 and N49B were subjected to a preliminary analysis, while 0453-68.5 underwent a more rigorous analysis. From the detailed analysis of 0453-68.5, we find an initial energy of 4.5×10^{50} ergs, and an age of approximately 12,000 years. In addition, the elemental abundances for the region of the LMC in which the supernova remnant is located were determined. For N49 and N49b, it was found that both remnants share some elemental abundance characteristics, which arises from their proximity, and N49 was found to be the younger of the two remnants.

22.   Studying Seebeck Effect

Oellig, Michael; Goksu, Mehmet*
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We studied thermoelectric characteristics of thermocouples and measured Seebeck coefficients of n-type and p-type of Silicon at different doping concentration in the temperature range of 295 and 315 K. We observed similar Seebeck coefficients and temperature dependence for the same kind of silicon materials. We also measured thermal conductivity of the semiconductor materials and then determined charge carrier density and ZT factor that is used as a measure of enhancement of the thermoelectric properties of semiconductor materials.

23.   X-ray Binaries and Cygnus X-1

Schmidt, Colleen; Hendrick, Sean*
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An X-ray binary is a system made up of a normal star and a compact object rotating about a common center of mass. The compact object pulls mass off of the outer atmospheres of the

normal star and the particles spiral down toward the compact object, creating what is called the accretion disk. Because of the internal friction caused by the spiraling particles, the disk heats up to millions of Kelvins and emits X-rays. There are three types of compact objects that can make up these systems: neutrons stars, white dwarfs, and black holes. In 1964, Cygnus X-1 was first discovered. It is the brightest X-ray source in the sky. It was determined that the object did not meet the requirements to be a neutron star or a white dwarf, so in the early 1970s, amidst much controversy, it was the first object to be labeled as a black hole candidate. The object can be found in 3 states: high/soft, low/hard or transition. The high and low classifications refer to how much mass is being accreted onto the disk at the time of observation. Soft refers to low energy X-rays and hard refers to high energy X-rays. Since the object cycles through the two states, a transition period also exists, which is a combination of both the high/soft and low/hard states. Data was collected by the high energy transmission grating (HETG) on the Chandra X-ray Observatory. The HETG is a diffraction grating for high and middle energy X-ray photons, and creates a series of spectra. It detects the first three orders on either side of the zeroeth order image for both the high and middle energies. For Cygnus X-1, the zeroeth order was far too bright to analyze. Spectra were extracted using CIAO, Chandra's data analysis software, and then analyzed in XSPEC. The different emission and absorption lines in the spectra will be used to examine the chemical composition of Cygnus X-1.

24.   Measuring the Force of Light
York, Joshua; Dooley, John*
Department of Physics, Millersville University, Millersville, PA 17551

A light source is directed onto a mirror that is magnetically levitated so that it will recoil in response to the force of the photons. By measuring the rotational response of the mirror assembly, the force is calculated. In order to minimize thermal effects due to energy dissipation in the form of heat, this experiment is performed under a high vacuum. The highest vacuum achieved was 1.4×10^{-6} torr with the force of a 19.1mW laser measured to be $(1.81 \pm 0.59) \times 10^{-11}$ Newtons. The expected value of the force of the laser is 5.88×10^{-11} N with eighty percent of the light transmitted through the glass of the vacuum chamber, forty-five percent reflected by the mirror, and twenty percent transmitted through the mirror.

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Millersville University

SEIZE THE **OPPORTUNITY**