2010 ISEF Projects

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Postcards from the Bay: A Comparison of Phytoplankton Population in Monterey Bay

Phytoplankton play a crucial role in the world's ocean: providing oxygen, a food source and a carbon sink. After quantifying the biodiversity of phytoplankton in Santa Cruz harbor last year, we have since expanded our focus to compare the abundance and diversity of phytoplankton at three additional sites: the North Santa Cruz Harbor and the Santa Cruz and Monterey Wharfs. This is the first time data from these sites has been compared, enabling us to determine if phytoplankton populations in the Monterey Bay Marine Sanctuary are influenced by location or other larger factors. We hypothesize that the two wharf locations will have a greater biodiversity and abundance of species than the harbor locations due to the harbor's limited access to the open ocean. Additionally, we predict that the biodiversity and abundance patterns of the wharf sites will be more similar to each other than the harbor sites. If true, this result could indicate that phytoplankton in the Sanctuary are influenced by broad factors rather than more localized conditions. To gather our data, we collect a sample of phytoplankton twice a month using a 20 & #956 mesh net from two sites in the North and South Harbor and record several environmental factors. We microscopically identify species and determine abundance. We then graph our data and compare it to data from Santa Cruz and Monterey Wharfs. This project was made possible by: Gregg Langlois (CDPH), Susan Coale and Jenny Lane (UCSC), and Dr. Jason Smith(MLML).

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Birds of Quail Hollow Ranch: A Study of Biodiversity

Quail Hollow Ranch County Park nestled in the foothills of the Santa Cruz Mountains is well-known for its natural diversity. Among the most understudied, however, is the avian life that is present at the park. This project was designed to provide an insight to the birds of the park, as limited information is known and no other documented, scientific study has been performed at this biologically important area. From the 1920s, Quail Hollow Ranch's landscape has changed dramatically. Formerly an open grassland surrounded by sand chaparral and sand parkland, mixed evergreen forest and riparian associated habitats have become dominant through secondary succession. As habitats appear and disappear, avian species do as well. Which led us to ask: What bird species are habitat specialists and what is their abundance? We have been informally birding Quail Hollow Ranch since 2003 and began a formal study late summer 2009 using binoculars, GPS and weather indicator. Through a process of weekly monitoring in point-count form, we are not only able to analyze and interpret which species are present at the park, but are also able to determine which habitats are imperative for these species to continue their presence at the park. In essence, this will provide a guide to what is being seen now and what will be seen later in time as ecological succession proceeds to transform the landscape.

Shamik Mascharak
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An Investigative Study on Pigmentation

Objectives: The goals of this project are a) to determine whether oxidation of Bilirubin leads to the bluish black pigment often noted in Pigmented Gall Stones in patients with hemolysis, b) does Copper (II) facilitate this oxidative process? c) What are the structures of the species involved? and d) What other metals participate in the formation of the stones?

Materials and Methods: Bilirubin (BR), Copper acetate and chloride, Zinc acetate, Calcium chloride, Potassium superoxide, cholesterol, deoxycholic acid, Varian 500 Megahertz NMR spectrometer, Bruker ELEXYS EPR spectrometer, Cary 50 UV/V is Spectrophotometer, Rainin Micropippetes, Glasswares.

By varying the ratio of Zinc acetate and Bilirubin in DMSO, the formulation of the Zn(II) complex of Bilirubin was determined first by spectrophotometry, and then by Nuclear Magnetic Resonance Spectroscopy. The structure of the Cu(II)-Bilirubin was investigated with the aid of spectrophotometry and Electron Paramagnetic Resonance spectroscopy. The stability of the two complexes was checked in both protic and aprotic solvents. The formation of bluish purple pigment by the Copper-BR complex at various pH was determined by spectrophotometry. Formation of pigmented solid by the pigment forming Cu-BR solution in presence of cholesterol, calcium salts and bile acid was carefully monitored over time. Finally, Electron Emission Spectroscopy was employed to confirm the presence of Copper and Calcium in both the synthetic and authentic gallstones.

Results: A 1:2 BR:Zn complex was identified in aprotic solvents. This complex readily decomposed in water. In contrast, the 1:1 BR:Cu complex (as determined by spectrophotometry and Electron Paramagnetic Resonance Spectroscopy), was found to be stable in aqueous solution. However, EPR measurements indicated the formation of radicals in such solution, presumably via redox cycling of the Cu (II) ion. This complex readily turned to a dark purplish blue color in air. The darkening reaction was accelerated by the addition of Potassium superoxide. In presence of cholesterol, bile acid, and calcium salts, the Copper-BR complex gave rise to a deep, bluish black residue over a period of days. Variation of reaction mixture pH indicated that a pH range of 6-8 is optimum for the formation of the pigmented residue. In aprotic solvents, the Cu-BR complex was stable and did not readily give rise to radicals (as indicated by EPR data). Close examination of the solid pigmented residues as well as authentic pigmented gallstones indicated the presence of Copper and Calcium ion.

Conclusions: Among the biologically relevant metal ions (Zn, Cu, Ca), only copper is redox active and initiates formation of O-based radicals in aqueous solution. A radical based polymerization of Bilirubin leads to bluish black pigment which imparts the signature color of pigmented gall stones from patients with hemolytic episodes.

Help Received: Nicole Fry, a graduate student at UCSC helped me in the NMR experiments. Christopher Dudzik, a graduate student in the Millhauser lab, provided assistance in the EPR measurements. The Electron Emission measurements were performed by Mr. Rob Frank of the UCSC analytical lab.

Marie Nielsen Biochemistry and Molecular Biology
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Lipid and Prion Interaction

Objective: How does a lipid membrane effect the octarepeat region of the prion protein (PrP)?

Materials and Methods
The latest versions of NAMD and VMD, the prion octarepeat region coordinates, organic component submolecular mass, energy and Van Der Waals force data for all the atoms in the octarepeat region, atomic mass, energy and Van Der Waals force data for Cu2+, the brain cell lipid membrane coordinates, and organic component submolecular mass, energy and Van Der Waals force data for all the atoms in the lipid are used for simulations. A lipid membrane is forced to interact with the octarepeat region (OR) of the PrP.

Results
The lipid membrane found in the brain has been linked to causing normal PrP to misfold into the neurodegenerative prions found in the diseases. There should be some change in the interaction energies of the PrP and the lipid membrane. This change might be an indicator of the prion misfolding or a contributing factor as to why the prion is misfolding.

Conclusion
It appears that the lipid is causing the PrP to misfold. This may be because of the interaction energy between the lipid membrane and the PrP.

Help Received
Thank you to Professor Glenn Millhauser at UCSC for helping guide my ideas as well as my parents for helping me with computer issues and proofreading.

Lara Tromba & Isabelle Tromba Environmental Sciences
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Title: Just Scum? Utilizing the Isotopic Signature of Macro-algae to Identify Sources of Nitrogen in Streams and Rivers Flowing into the Monterey Bay, California.

1. Introduction:

In the US alone, anthropogenic sources of nitrogen to the environment have doubled over the last 50 years. Santa Cruz County and Monterey County surround the Bay and have large agricultural land use. Macro-algae assimilate the nitrogen in the water and therefore reflect the nitrogen isotopic signature of the water. By utilizing the isotopic signatures of macro-algae in conjunction with USGS and Santa Cruz County Hydrological data, we will be able to identify the sources of nitrogen. The study's sample sites range from the northernmost site Waddell Creek to the southernmost site, Big Sur River and sampling dates range from 5/27/08 to 12/20/09. The large geographical and seasonal range of data will provide a large span of information to better understand the impact of anthropogenic nitrogen on streams and rivers.

Goal: To identify the source of nitrogen in streams and rivers flowing into the Monterey Bay.

We expect to see a positive correlation between agricultural land use and delta 15 N values of macro-algae. Results and conclusion are pending because our samples have not been run through the ratio gas mass spectrometer (but will be next week).

2. Methods:

Sample Collection: Algae samples were taken from the perimeter of the streams and rivers. They were placed into 50mm x 9mm petri dishes and stored in a cooler. Once all samples were collected, they were transferred to a freezer until they could be taken to the lab to be dried.

Laboratory Procedure: Samples were placed in a 50°C oven for a minimum of 48 hours to ensure removal of all moisture. Samples were then ground to a fine powder with a mortar and pestle and transferred into small sample bottles (careful cleaning precautions were taken using laboratory KIMTECH Kimwipes® in order to ensure no cross-contamination). Complete homogenization of samples was crucial for stable isotope analysis. A micro-balance was used to weigh 2.00 3.00mg of algae into 3.5mm x 5mm tin capsules. Exact weights were recorded for each sample. The samples were then run through a Carlo Erba 1108 elemental analyzer coupled to a ThermoFinnigan Delta Plus XP isotope ratio mass spectrometer (IRMS) at the Stable Isotope Laboratory at the University of California, Santa Cruz.

3. Pending

4. Pending

5. Adina Paytan, a UCSC research professor, and our advisor, Darrel Steely, helped us gain access to a UCSC laboratory.