Natural Sciences Summer 2016 Undergraduate Research Program

MENTOR *Department*	**RESEARCH TITLES & ABSTRACTS**
Dr Eric E. Finney *Chemistry*	**Activation and Incorporation of Carbon Dioxide into Organic Molecules** The activation of carbon dioxide by organic substrates and organometallic complexes will be studied. The overall goal of this research is the conversion of carbon dioxide to potential fuel sources (formic acid, methanol, etc.) or its incorporation into organic molecules as a way to use CO2 as a useful synthetic building block.
Dr Jon O. Freeman *Chemistry*	**Development of a fluorescent screen to detect botryococcene production in an *E. coli* host** Our current project is aimed at establishing a fluorescent screen capable of identifying botryococcene production in *E. coli*. This screen can then be used as a means of selecting mutant strains of *E. coli* with enhance biofuel production. This will be accomplished by investigating and engineering proteins related to the biofuel production. Libraries of mutant proteins will be developed and assessed for increased biofuel output. Selecting mutants with increased biofuel production will be accomplished by employing our fluorescent screen. This screen will allow for the quick identification of microbes capable of producing biofuel and allow for a general quantification of biofuel production based on fluorescence activity. Mutant proteins of interest will result in a fluorescing microbe while mutant proteins with reduced activity will yield diminished or no fluorescent activity. Fluorescing microbes will be sorted and selected using fluorescence-activated cell sorting techniques. This project will lead to the development of proteins capable of producing optimal amounts of biofuel and contribute to our understanding of biofuel biosynthesis.
Dr Adam C. Glass *Chemistry*	**Highly Functionalized Benzofulvenes: Targeting Thioredoxin Reductase via Small Molecule Drug Development** A rational small molecule drug design project has been implemented utilizing highly functionalized benzofulvene motifs for the inhibition of human thioredoxin reductase 1. Thioredoxin reductase along with its substrate (thioredoxin) have been implicated in a host of biological processes; namely managing the cellular redox environment, inter and intra-cellular communication and cancer progression. The salient function of thioredoxin reductase is managing the redox cycle of thioredoxin. Overexpression of thioredoxin reductase and elevated levels of thioredoxin have been observed in many cancer types, especially those considered to be aggressive. Furthermore, thioredoxin is a known activator of many cellular growth based devices, including: transcription factors (e.g., AP-1, SP-1), and angiogenesis (e.g., VEGF) among others. It is also a known inhibitor of apoptosis signal-regulating kinase (ASK-1). The inhibition of thioredoxin reductase has been proposed as a possible small molecule therapeutic target for treatment of aggressive tumor types. We propose the use of highly functionalized aromatic motifs as a basis for lead drug design targeting the active site of thioredoxin reductase.
Dr Rosemarie C. Haberle *Biology*	**Phylogeography of Pacific Northwest Bluebells (Campanula: Campanulaceae) and phylogenomics of North American Campanulaceae** This project investigates flowering plant species boundaries, evolutionary relationships, and population-level gene flow within/between Pacific Northwestern (PNW) Campanula. Scouler's Bluebell (Campanula scouleri) is a relatively common, but sporadic herbaceous perennial, which grows in mixed conifer forests along the western Cascades and PNW coastal ranges, including the Olympic Mountains and down into Northern California. Summer 2016 research will focus on comparative plant community composition and structure using field and herbarium studies, while completing sampling for future population genetic analysis.

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Dr Katrina M. Hay & Dr Sean M. O'Neill *Physics*	**Observational Astronomy Research at PLU's Keck Observatory** We propose to mentor two students in astronomy research at PLU's Keck Observatory. The goal of this research project is to provide talented and enthusiastic undergraduates with the opportunity to gain hands-on experience taking real astronomical data and analyzing this information with standard astronomical research methods. The major projects, involving observations of the Sun and Jupiter, are designed to provide an accessible and rewarding research experience, while an assortment of secondary projects will deliver a fulfilling introduction to the subtle details of astronomical data processing.
Dr Alex R. Lechler *Geosciences*	**Clumped isotope record of last glacial period paleoclimate across the Pacific Northwest United States** The last glacial period (~ 125,000-10,000 years ago) marks a period of significant global climate cooling during which continental glaciers and ice sheets expanded and covered much of the Pacific Northwest. Despite copious research into the causes and impacts of global cooling, fundamental questions remain on the quantitative magnitudes of climate change and degree of regional variability. This study will use carbonate clumped isotope thermometry study of Palouse loess soil carbonate to provide new, quantitative, and direct measures of last glacial period surface temperatures in the Palouse region of eastern Washington state. These quantitative constraints will inform understanding of the mechanisms and outcomes of global and regional climate change in the past, in turn, enhancing capabilities to predict and simulate future climate change and associated climate change impacts .
Dr Justin C. Lytle *Chemistry*	**Studying the rate of redox reactions on battery electrodes** Batteries and capacitors are essential and ubiquitous in portable electronic devices, yet challenges remain to increase the amount of energy that batteries and capacitors can store and the rate at which they can store and then release it. In response to this need, researchers have developed porous carbon nanofoam electrodes; their large surface areas enable redox reactions to occur at higher rates than planar, non-porous electrodes. One recent challenge is that while redox reactions on carbon nanofoams occur more rapidly than they do on low-surface-area electrodes, these reactions occur over a wide gradient of potentials (Volts) and to lesser extents than on electrodes that have greater electronic conductivities. Students in Dr. Lytle's research group will investigate this phenomenon by fabricating thin-film electrodes and then using cyclic voltammetry data to calculate the rate that electrons move from electrode surfaces to the metal-centers in redox-active complexes .
Dr Andrea M. Munro *Chemistry*	**Synthesizing Nanoparticles to Optimize Luminescent Solar Concentrator Photocatalysis** Students in the Munro Research Group will synthesize novel doped semiconductor nanocrystals and metal nanoparticles for use in luminescent solar concentrators (LSCs) and LSC photovoltaics. The student will work as part a collaborative research alliance that brings together scientists from George Fox University, Pacific Lutheran University, the University of Puget Sound, and Western Washington University. The goal of the alliance is to investigate LSC devices that focus sunlight spatially and convert shorter wavelengths of light to longer wavelengths for higher efficiency conversion to electrical energy in photovoltaic solar cells. We will also investigate LSCs as high-brightness, narrow-band light sources for photocatalytic applications.

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Dr Shannon B. Seidel *Biology*	**Developing Tools to Measure What Teachers Do: Quantitative Assessment of Active Learning Using the Decibel Analysis Research Tool (DART)** Nationally, there is strong interest in developing tools to measure undergraduate teaching methods in STEM (Science, Technology, Engineering, and Mathematics). Indeed, the National Science Foundation (NSF) and the American Association for the Advancement of Science (AAAS) recently released a report on this topic to discuss currently available tools and the challenges these tools pose. Currently, no tool exists that could quickly and systematically measure the proportion of faculty doing anything other than lecture in a classroom. In an effort to design a tool that can consistently provide a systematic, quick, and inexpensive assessment of the types of activities being used in undergraduate science courses, I have (in collaboration with researchers at SFSU: San Francisco State University) developed DART: the Decibel Analysis Research Tool. Preliminary studies, completed during my postdoctoral fellowship showed that measuring classroom noise levels through decibel monitoring can generate an objective measure of the instances and duration of a variety of classroom activities including pair discussions, minute papers, and other teaching strategies. Whereas preliminary evidence has shown the potential of DART, additional research into the benefits and limitations of this tool remain to be completed. Our first large dataset (over 900 hours of classroom audio from >30 different classrooms) collected during the 2014-2015 academic year, now requires analysis and presents a critical opportunity for important contributions by undergraduate researchers.
Dr Dean A. Waldow *Chemistry*	**Ring Opening Metathesis Polymerization and Characterization of Oxanorbornene Polymers Towards Improved Energy Related Battery and Fuel Cell Electrolyte Membranes** Ring opening metathesis polymerization (ROMP) will be used to continue synthesizing two classes of diblock copolymers and homopolymers with applications in battery membrane technology and in fuel cell membrane technology. The diblock copolymer structures synthesized will develop nanometer morphologies potentially allowing these materials to improve performance of lithium ion batteries and in the hydrogen or reformation based fuel cells. The nano-morphology of these materials will be studied as a function of block molecular weight allowing lamellar, cylinder, sphere, and gyroid morphologies to be produced on a sub 100 nanometer length scale. Subsequently, the influence of the nano-morphology on ionic motion will be investigated. One block in each material will allow for both thermal and structural support while the second block will provide ion mobility. The materials will be characterized using many instruments (e.g., NMR, GPC, AFM, and electrochemistry) at PLU, dielectric spectroscopy at PLU and the University of Tennessee – Knoxville, at the University of Washington (SAXS), and potential analysis from SANS instrumentation from Oak Ridge National Laboratory user facility or other similar location.
Dr Neal A. Yakelis *Chemistry*	**Controlled release of pharmaceuticals via the retro-Diels-Alder reactions of drug-polymer conjugates** A leading strategy for selective- and sustained-drug release is the attachment of drug molecules to biocompatible materials using a linking group that can be stimulated to release the drug under specific conditions in the body. A “traceless” linker that is thermally-sensitive will offer a versatile path to the delivery of pharmaceuticals by a retro-nitroso-Diels-Alder reaction. The rates for release of provitamin D and sulfonamide drugs will be measured in model systems in order to determine how structural features tune reactivity. Ways to efficiently, covalently load drugs on to the "trigger" units of the polymer is also an important focus of our research. Monomers based on these models will then be incorporated into the desired polymer-drug conjugates. Light-initiated processes can also be explored as a way to induce the retro-nitroso-Diels-Alder reactions.