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Micro- and nano-electronic components and devices have increasingly been combined with biological systems [2] like medical implants , biosensors , lab-on-a-chip devices etc. Biomaterials â€” any matter, surface, or construct that interacts with biological systems. As a science, biomaterials is about fifty years old. The study of biomaterials is called biomaterials science. It has experienced steady and strong growth over its history, with many companies investing large amounts of money into the development of new products. Biomaterials science encompasses elements of medicine , biology , chemistry , tissue engineering and materials science. Biomedical science â€" healthcare science, also known as biomedical science, is a set of applied sciences applying portions of natural science or formal science , or both, to develop knowledge, interventions, or technology of use in healthcare or public health. Explaining physiological mechanisms operating in pathological processes , however, pathophysiology can be regarded as basic science. Biomonitoring â€" measurement of the body burden [4] of toxic chemical compounds , elements , or their metabolites , in biological substances. Since they are polymers , biopolymers contain monomeric units that are covalently bonded to form larger structures. There are three main classes of biopolymers, classified according to the monomeric units used and the structure of the biopolymer formed: Food science â€" applied science devoted to the study of food. Activities of food scientists include the development of new food products, design of processes to produce and conserve these foods, choice of packaging materials, shelf-life studies, study of the effects of food on the human body, sensory evaluation of products using panels or potential consumers, as well as microbiological, physical texture and rheology and chemical testing. The field also includes studies of intragenomic phenomena such as heterosis , epistasis , pleiotropy and other interactions between loci and alleles within the genome. Kinesiology â€" Kinesiology, also known as human kinetics, is the scientific study of human movement. Kinesiology addresses physiological, mechanical, and psychological mechanisms. Applications of kinesiology to human health include: Play media Parasagittal MRI of the head, with aliasing artifacts nose and forehead appear at the back of the head Medical imaging is the technique and process used to create images of the human body or parts and function thereof for clinical or physiological research purposes Optogenetics â€" Optogenetics is a neuromodulation technique employed in neuroscience that uses a combination of techniques from optics and genetics to control and monitor the activities of individual neurons in living tissue â€"even within freely-moving animalsâ€"and to precisely measure the effects of those manipulations in real-time. Spatially-precise neuronal control is achieved using optogenetic actuators like channelrhodopsin , halorhodopsin , and archaerhodopsin , while temporally-precise recordings can be made with the help of optogenetic sensors like Clomeleon, Mermaid, and SuperClomeleon. More specifically, it is the study of the interactions that occur between a living organism and chemicals that affect normal or abnormal biochemical function. If substances have medicinal properties, they are considered pharmaceuticals. Population dynamics â€" Population dynamics is the study of short-term and long-term changes in the size and age composition of populations , and the biological and environmental processes influencing those changes. Population dynamics deals with the way populations are affected by birth and death rates , and by immigration and emigration , and studies topics such as ageing populations or population decline. Proteomics â€" Proteomics is the large-scale study of proteins , particularly their structures and functions. The proteome is the entire set of proteins, [34] produced or modified by an organism or system. This varies with time and distinct requirements, or stresses, that a cell or organism undergoes. University of California Press.

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Chapter 2 : List of life sciences - Wikipedia

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Below are examples of research projects within the Chemistry Summer Undergraduate Research program. These change annually based on the interests of students and faculty. Please also see chem. Each summer, we have projects that emphasize synthesis, exploration and discovery, analysis, and computation, as well as combinations of these in collaborative teams of scientists. We encourage you to consider not only projects of interest but also those that extend and enhance your learning. Enzymes within the radical S-adenosylmethionine SAM superfamily catalyze a dazzling array of chemical transformations that proceed via free radical intermediates. This project will focus on developing methods to annotate the functions of RS enzymes catalyzing unknown reactions. Students will learn how to generate sequence similarity and genome neighborhood networks to provide insight into function via 9 bioinformatics methods. They will also learn molecular biological techniques, such as cloning and site directed mutagenesis and gene expression. It is well known that protein enzymes catalyze a diverse array of chemical reactions with exceptional rates and specificity. RNA is comprised of only four similar nitrogenous heterocycles, yet it too can catalyze chemical reactions and do so with remarkable rate acceleration and specificity. The surprising discovery that RNA can catalyze reactions is relatively recent and led to the Nobel Prize in Chemistry in This project will employ interdisciplinary approaches to understand how RNA catalyzes reactions. Students will be engaged in a combination of molecular biology, chemical kinetics, and bioanalytical techniques. In addition, there is the option to study chemical reactions that may have formed the first RNAs that were then copied to begin life. Elucidating the broad reaction profiles of iron and 2- oxo glutarate-dependent enzymes Faculty Mentors: The most exciting new directions concern several enzymes that mediate two or three distinct reaction types e. These sequential and divergent reactivities are certain to involve dynamic repositioning of substrates within the enzyme active sites to enable different substrates, different positions on the same substrates, or different outcomes to be targeted within the same active site. The combination of novel chemical mechanisms and active-site structural dynamics will make for rich vehicles for excited, aspiring young biochemists and biophysicists to study modern enzymology. Trapping and spectroscopic investigation of metalloenzyme reaction intermediates Faculty Mentor: Alexey Silakov Project Description. Metalloenzymes catalyze a wide variety of difficult reactions that, in a majority of cases, require a chain of chemical transformations. The Silakov group is interested in a novel hybrid class of metalloenzymes containing two catalytically active domains: It is hypothesized that hydrogen is heterolytically cleaved by the [Fe-Fe] hydrogenase domain to provide electrons and protons, which in turn are used by the di-iron site of rubrerythrin to reduce hydrogen peroxide to water. This REU project will focus on understanding the interaction between the two domains by means of trapping and characterizing intermediates in the reaction. Students will also be provided with an opportunity to perform theoretical modeling of the experimental data using EPR simulation software and perform density functional theory calculations. Dynamics of Biological Processes Project 5: RNA viruses, including Zika, Ebola, hepatitis C and poliovirus, cause a number of acute and chronic diseases. Our insights can be leveraged towards the rational design of new anti-viral drugs and vaccines. REU students on this project will learn state-of-theart, high-dimensional NMR techniques as they pertain to understanding protein structure and dynamics. These NMR methods will be complemented by other spectroscopic and calorimetric methods, along with other biochemical and molecular biology techniques. Engineering new regulatory activities into enzyme catalysts Faculty Mentor: David Boehr Project Description: The Boehr lab is interested in the development and engineering of new stimulusresponsive enzyme catalysts. Enzymes can be viewed as small-world networks of amino acid residues connected through noncovalent interactions. Using solution-state NMR methods, we have identified amino acid networks that stretch from the surface of enzymes into their active sites. An REU student on this project will learn approaches to covalently modify proteins, protein NMR methods to identify changes to the amino acid network, and kinetic and biological methods to determine changes to enzyme function. These studies can be leveraged towards designing new biological systems for improving applications in industry and biomedical research, including the biological syntheses of new fuels and pharmaceuticals. Probing glutathione trafficking in cell Faculty Mentor: Joseph Cotruvo Project Description: Glutathione GSH is a ubiquitous thiol-containing tripeptide present at millimolar concentrations in eukaryotes and many prokaryotes. Although the effects of alterations in GSH redox potential are well known, dramatic yet regulated fluctuations in total GSH levels also occur during apoptosis and as a part of the normal cell cycle in nuclei. GSH is also elevated in many cancers. The mechanisms and physiological targets of these redistributions are almost completely unknown. The Cotruvo lab has developed protein-based fluorescent sensors that respond to GSH selectively and that can be targeted to organelles to probe the proteins involved in GSH movement within cells. In this project, students would aid in sensor optimization and targeting to organelles of interest, and investigate putative transporters via genetic knockdown. The REU student would gain experience in a variety of biochemical and chemical biology methods such as protein engineering, protein purification, molecular biology, mammalian cell culture and transfection, and confocal microscopy. Understanding Macromolecular dynamics Faculty Mentors: A central problem in modern physical biochemistry is to quantify the conformational dynamics of highly flexible biological macromolecules, such as intrinsically disordered proteins, and then to establish the connection between those dynamics and molecular function. This REU project will focus specifically on the role of conformational dynamics in producing specific and reversible proteinprotein and protein-nucleic acid interactions that drive the process of gene transcription. REU students will gain experience with recombinant protein expression in bacterial cell culture as well as protein purification and characterization. Depending on the interests and background of the individual student, projects will emphasize different areas of analytical and physical chemistry, including high-resolution NMR spectroscopy, mass spectrometry, micro-calorimetry, and functional assays involving introductory mammalian cell culture, as well as computational analyses to generated detailed molecular structure sets for highly flexible biomolecules. It has been found that receptor molecules, such as porphyrins, nanoparticles and proteins, can migrate up a concentration gradient of their corresponding ligands. This phenomenon, which is called chemotaxis, may have physiological consequences and can be exploited to create a new generation of nanomotors that respond to subtle changes in the chemical environment of the surrounding medium. We are exploring ligand-receptor binding systems to determine the underlying molecular mechanism of this process as well as to build a new generation of devices that can produce chromatographic separation of receptor materials. Significantly, many of the proteins that display chemotaxis are also enzyme-based catalysts wherein their ligand fuel may provide a direction of motion for the substrate. Students involved in this project will obtain a unique opportunity to study the motion of nanomaterials using novel spectroscopic techniques as well as help in the development of microfluidic platforms and assays. Ayusman Sen Project Description. REU projects will involve the design, characterization, and study of autonomous, chemically powered, particles. One of the projects will involve the fabrication of bimetallic nanorods and the examination of their movement arising from redox reactions occurring at the two-ends of the rods. The second project will involve the synthesis of enzyme-anchored particles powered by catalytic reactions and the study of their collective behavior in the presence of external and internal stimuli. Such systems can be further configured to observe predator-prey behavior among the swimmers, where groups of particles functionalized with different enzymes will form interaction cascades and display emergent dynamic patterns. The projects will expose the REU students to a variety of synthesis and materials characterization techniques, More broadly, the students will learn how chemistry, physics, nanotechnology, and fluid dynamics can be integrated to create synthetic materials that exhibit unprecedented biologically-inspired behavior. The specific activity of enzymes changes depending on the rate at which the ribosome synthesizes the enzyme during the elongation phase of translation. The molecular origins of this phenomenon is unknown, although the most likely hypothesis is that translation kinetics alters cotranslational folding events that influence the population of soluble, but kinetically-trapped non-functional protein molecules. The goal of this project is to understand the extent to which protein structure around the active sites of enzymes can be perturbed by changes in codon translation rates. REU students will gain experience in computer coding, molecular dynamics simulations, and statistical and kinetic analyses of simulation trajectories. And ultimately, they will help contribute to the emerging paradigm about how kinetics more than thermodynamics determines protein structure and function. New Insights into Chemical Catalysis Project Tom Mallouk Project Description: The electrochemical reduction of carbon dioxide CO2 may provide an economical means of storing renewable energy - generated as electricity from wind or sunlight - in the form of liquid fuel. This program focuses on the discovery of better electrocatalysts for the reduction of CO2 to small molecule feedstocks for the synthesis of liquid hydrocarbons. In this project, REU students will synthesize bi- and trimetallic alloy catalysts and characterize them structurally and electrochemically. Structural characterization techniques will include X-ray powder diffraction, electron microscopy, and X-ray photoelectron spectroscopy. Students will use electrochemical methods to measure the onset potentials for CO2 reduction and proton reduction as a function of catalyst and additive composition. Product distributions will be measured by gas chromatography. The choice of catalyst materials will be guided by theoretical and mechanistic considerations. Ray Schaak Project Description: In this project, REU students will engage in multi-disciplinary efforts to discover new heterogeneous catalysts that are relevant to applications in solar energy conversion, fuel cells, and target-oriented organic synthesis. Representative types of catalytic transformations include the oxygen evolution reaction, the oxygen reduction reaction, CO2 reduction, and selective hydrogenations and oxidations. Students will first synthesize a variety of solid-state materials as nanoparticles, films, powders, and single crystals, and then analyze them using a suite of materials characterization and catalytic testing techniques. Inspiration for target catalytic materials will be drawn from computational and mechanistic predictions, as well as from structural and compositional analogies with known homogeneous and biological catalysts. Benjamin Lear Project Description: Catalysis is the foundation of the modern chemical economy, allowing the accomplishment and commercialization of reactions that would otherwise be cost and energy prohibitive. The traditional means of increasing catalytic efficiency is to modify the catalyst to lower the barrier for any given specific reaction. This REU project will focus on understanding how to use the properties of nanoparticles to control more precisely the distribution of this heat, and to understand the impact that this increased control has over the efficiency of catalyzed reactions. Students involved in this project will design and synthesize nanoparticle systems and characterize these systems using microscopy and diffraction techniques. They will then incorporate the nanoparticles into catalytically primed reaction mixtures and measure the efficacy of the photothermal effect for driving catalysis using a variety of analytical techniques. A central problem in the development of solar power as an alternative energy supply is the ability to store the energy for later use when the sun is not shining. Catalytic materials based on inexpensive and earth-abundant elements are attractive alternatives to noble metal and rare-earth catalysts. This REU project will work toward development of new earth abundant nanocrystalline materials systems that enable high efficiency photocatalysts for hydrogen production and oxygen evolution. This REU project will involve use of inorganic solution chemistry methods to synthesize novel metal-phosphide catalysts with a variety of structures. These catalysts will be coupled to light absorbing copper-zinc-tin-sulfide nanocrystals to combine light harvesting and catalysis together in the same system. The corresponding surface chemistry and photocatalytic activity will be characterized by monitoring the evolution of hydrogen and oxygen gases.

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Chapter 6 : Careers in Science

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