

Science Division Summer 2009 Research Proposals

#	Supervisor	Department	# of students	Project Title and Description
1	Blankespoor, Curt Koetje, David	Biology	2	Developing Learning Modules for Biology 123, a New Problem-Based Course for Biology Majors Biology 123, a new course for majors in the biology department, is intended to promote the development of critical thinking and problem-solving skills for first-year students. Course topics will include global climate change, human races, stem cells, biodiversity, and infectious disease. Summer researchers will work with faculty in biology and other departments to identify appropriate learning materials and activities, organize them into effective learning modules, and assemble them into a course manual. Students may also have opportunities to contribute to a manuscript for publication and other materials for dissemination.
2	DeJong, Randall	Biology	1	Immunobiology of Biomphalaria snails, hosts for Schistosoma mansoni Schistosoma mansoni is a parasite of humans that requires Biomphalaria snails as part of its life cycle. Understanding interactions between the parasite and its invertebrate host could lead to development of resistant snails that could reduce transmission. Resistant and susceptible lines of snails will be used in investigations of the genes and proteins that play a role in determining compatibility. Modern molecular laboratory techniques of qPCR and RNAi, among others, will be utilized.
3	Dornbos, David	Biology	1	Characterization of Woody Invasive Shrubs as Potential Sources of Biomass for Cellulosic Ethanol Fossil fuel derived energy is becoming increasingly expensive and contributes to a significant carbon footprint. Many have speculated that renewable resources must be developed and that one of the most promising options is cellulosic ethanol. Switchgrass and corn stubble are widely recognized as prime sources of biomass for ethanol. Both species are fast-growing, prairie adapted, C4 grasses. Michigan is not characterized today by extensive prairies, however, so these grasses may not represent the best sources of biomass from abandoned and degraded fields where the climate tends to be cool and moist. Comparison of photosynthesis rate of woody invasive shrubs with co-existing native shrubs demonstrates the potential of these invasives to rapidly produce large quantities of biomass. The goal of this research is to establish field trials comparing biomass accumulation rates of buckthorn, autumn olive, and switchgrass; and, to optimize the biomass production capacity of these perennial shrubs while minimizing their invasive capacity.
4	Grasman, Keith	Biology	1	Impact of Environmental Contaminants on Immune Function in Common Loons The deposition of airborne mercury into lakes in the northeastern US and Canada presents significant health risks to fish-eating wildlife such as common loons. In a previous laboratory study, dietary mercury exposure suppressed immune function in young loons. This study will investigate immunological effects in wild loons in the Adirondack Mountains of New York, and possibly (contingent upon funding). Loons will be captured at night. White blood cells will be isolated from blood samples and cryopreserved for transport back to the laboratory at Calvin. Immunological functions of these white blood cells will be assessed using cell culture and flow cytometry assays.
5	Grasman, Keith	Biology	2	Effects of Pollutants on the Health of Colonial Waterbirds of the Great Lakes Fish eating birds are effective “sentinel species” for assessing toxic effects on the health of the Great Lakes ecosystem. Our previous studies have shown associations between pollutants and suppressed immune and hormonal functions in gulls, terns, and herons of the Great Lakes. The objective of the current study is to continue the assessment and monitoring of these health effects at contaminated sites in the US and Canada. This project involves travel and boating for field work around the Great Lakes and follow-up laboratory work at Calvin.

6	Hoogewerf, Arlene	Biology	1	Heavy Metals and Resistance Mechanisms in Bacteria Some heavy metals, when present at low levels, are essential for cell metabolism, but at higher concentrations are toxic to cells. Heavy metals are present in the environment due to industrial processes. Some prokaryotes have mechanisms that allow survival in the presence of toxic concentrations of heavy metals, and these mechanisms may be similar to antibiotic resistance mechanisms. Some strains of Methicillin-Resistant Staphylococcus aureus (MRSA) include on their chromosome genes that are similar to cadmium-resistance operons only previously found in plasmids. We would like to functionally characterize a chromosomally-encoded cadmium resistance operon in S. aureus ATCC12600, a non-MRSA strain with a cadmium-resistance operon. In addition, the relationship between heavy metal resistance and virulence mechanisms such as biofilm formation and antibiotic resistance will be investigated.
7	Hoogewerf, Arlene	Biology	1	Biofilm Bacteria & their Mechanisms to Evade Host Cell Defense Bacteria that exist in communities called biofilms are more resistant to antibiotics, chemical disinfectants, and host defenses. Students will use bacterial and cell culture methods to grow bacteria and macrophages, and will use fluorescent and biochemical methods to examine the effects of mediators released from one cell type on the growth of the other cell type. In addition, students will examine transposon mutants and transformed bacterial strains to determine which gene products interact with host cell mediators. This work will contribute to a better understanding of how biofilm bacteria are better able to resist host defenses and cause recalcitrant infections.
8	Matheson, Stephen	Biology	1	Modeling of cytoskeletal dynamics and interplay with control of gene expression The student will use the systems biology programming language called Little b to create a dynamic virtual model of the function of an intracellular regulatory network controlling the cytoskeleton and the expression of related genes. Little b is fairly easy to use and learn, and the biological concepts are somewhat basic, so students from either computational or biological backgrounds would be welcome to apply.
9	Matheson, Stephen	Biology	1	Formin function in cell migration Formins are cytoskeletal regulatory proteins that control both actin and microtubules. In mammals, the gene family includes at least 15 members, but only a few have been studied in any detail and their effects on basic cell biological processes such as cytokinesis and cell migration are unknown. The student will use immunoblotting and quantitative PCR to measure expression of formin expression, then use RNA interference to knock down expression of formins, individually and in combination, to test the hypothesis that formin proteins specialize in their control of cell migration.
10	Shen, Anding	Biology	1	A novel pathway for activation of resting CD4+ T cells and re-activation of latent virus in the SIV/macaque model of HIV-1 latency There are many ways to activate resting CD4+ T cells mostly involving T cell receptor and cytokines, however, we discovered a novel method to activate resting T cells independent of either T cell receptor or cytokines. This activation pathway also re-activates latent virus in resting CD4+ T cells. We already know it involves the interaction between cell surface molecules CD58 and CD2. This project is to find out detail mechanisms involved in T cell activation and viral re-activation. This study will take place most likely at Johns Hopkins University in Baltimore Maryland.
11	Ubels, John	Biology	1	Development and evaluation of lubricant eye drops for treatment of dry eye syndrome Lubricant eye drops (artificial tear solutions) are used to alleviate the signs and symptoms of dry eye disease. This project involves the development and evaluation of new artificial tear formulations. These formulations must be tested for safety and efficacy. A major focus of this project is the use of in vitro models using corneal cells in culture and with application of instrumentation including flow cytometry, fluorimetry and fluorescence microscopy to determine effects of formulations and their components on cell morphology and function. Experience in cell culture is preferred but not required.

12	Van Dragt, Randall	Biology	1	Role of Invertebrates in the Food Web of Flat Iron Lake Several members of the Biology Department are involved in a multi-year study of the biotic communities represented at the College's new Flat Iron Lake Nature Preserve. Last year we began a study of the plant and animals communities of Flat Iron Lake itself. That study described the species occupying the upper trophic levels of the ecosystem. This study will begin to quantify the communities at the base of the food web. This study has two major components only one of which will be pursued during the summer of 2009. The first component concerns the planktonic community of the open waters. The second will examine the macroinvertebrate of the zone of emergent vegetation at the margins of the lake (littoral zone). Which project is pursued will depend in part on the interests of the student.
13	Van Dragt, Randall	Biology	2	Stewardship of the Ecosystem Preserve Each summer two students are employed to steward the Calvin College Ecosystem Preserve. The position involves a variety of maintenance activities (approximately 40%) and several long-term research projects (60%). This summer the research projects will involve a census of breeding birds conducted across the entire preserve, a sampling of small mammals in three preserve habitats and a census of the tree populations at the heart of the preserve.
14	Warners, David	Biology	2	Forest Creation and Natural Areas Restoration on the Calvin College Campus This project will build on the efforts from the past two years in which four new areas of forest have been introduced onto the college campus as partial mitigation for the loss of forest habitat incurred by the construction of the Spoelhof Complex and the new Van Reken dormitory. Students will monitor and manage the habitat creation efforts that have begun, and transplant new vegetation into these sites as needed. They will collect data from a replicated restoration experiment in the Burton Street site, process the data using standard biostatistics, and develop a scientific report on their findings. In addition, this project will involve continued efforts to eliminate non-native species from our campus natural areas and care for earlier, more established native plantings on campus.
15	Warners, David	Biology	1	Documenting Vegetation Dynamics and the Socio-Historical Context of the Flat Iron Lake Preserve This project will build on the baseline botanical inventory and phenology that is developing for Calvin's Flat Iron Lake Preserve. As global climate change progresses, we intend to carefully document the shifts in vegetation dynamics that are occurring. Therefore, this study will not only add to the botanical inventory of the site but will also record flowering periods for many of the dominant plants that occur here. In addition this work will also begin documenting the human history of this area. Calvin's recent presence in this rural community necessitates an understanding of the historical context in which we now find ourselves. In short, to be good neighbors, we must get to know the local community and develop an understanding of the changes that have been incurred by this landscape over time. To that end, this student will interview local inhabitants, many of whom belong to the Calvin Wittenbach family, and research local township archives. The result of this effort will be a written historical account of the changes in the land that have occurred during the past century.
16	Wertz, John	Biology	1	Cultivation and Characterization of Microaerobes from the Human Microbiome It has become increasingly obvious that microorganisms residing within the human intestine (the gut microbiome) have enormous health impacts. They help digest food and produce sources of energy, excrete vitamins, stimulate a healthy immune system, and prevent disease. However, it is also known that 90% of these microbes have yet to be cultivated and studied. Students will use a PCR-based technique to construct a "microbe library" of numerous unique species of bacteria biopsied from the human intestine, then do physiological experiments that will go beyond simple identification to answering questions about the ecology of the organism in its environment and potential impacts on the human host. This will include growth analyses and various enzymatic and biochemical assays. This work will provide a better understanding of microbial interactions with each other and the human host, giving insight into the mechanisms of intestinal disease.

17	Wilstermann, Amy	Biology	1	<p>Characterization of Intermolecular Interactions that Influence Topoisomerase II-mediated DNA Scission</p> <p>Topoisomerase II is an essential enzyme that plays a critical role in virtually every DNA process. This enzyme creates a transient double-stranded break in the genetic material and upon ATP binding passes a second, intact DNA helix through the break. Since the activity of this enzyme is essential, the inhibition of topoisomerase II can cause cell death; a strategy employed by a number of anticancer agents. In order for topoisomerase II to complete strand passage, it must bind and hydrolyze ATP. The goal of this project is to characterize the intermolecular interactions that occur between topoisomerase II and its ATP cofactor as well as interactions that occur between the enzyme and chemotherapeutic agents that act as competitive inhibitors at the ATP-binding site and therefore inhibit topoisomerase II activity. These interactions will be investigated using both biochemical and biophysical techniques. An improved understanding of these interactions may contribute to the development of compounds with greater efficacy against topoisomerase II.</p>
18	Wilstermann, Amy	Biology	1	<p>Investigation of Prokaryote-Stimulated Expression of Eukaryotic Matrix Metalloproteinases</p> <p>Collagen is an important component of the extracellular matrix (ECM) and proteins able to degrade collagen are involved in a wide variety of biological processes including fetal membrane weakening which plays a role in both term and preterm membrane rupture (PROM). Matrix metalloproteinases (MMPs), eukaryotic enzymes capable of degrading collagen, are activated and/or expressed to a greater extent in membranes that rupture prematurely. Another factor associated with PROM is bacterial vaginosis (BV), an infection in the reproductive tract. Characterization of reproductive tract bacterial communities in women with and without BV found much greater prokaryotic diversity in the BV communities. Furthermore, some of the prokaryotic species identified in the BV communities are known producers of collagen degrading enzymes. Interestingly, it has been shown that latent MMPs in some eukaryotic cells, can be activated by collagenolytic proteases produced by bacteria, suggesting that prokaryotic proteases may play an indirect role in the ECM degradation associated with premature fetal membrane rupture. This study aims to (i) further characterize the bacteria that are associated with PROM, (ii) identify those prokaryotes that are able to produce collagen degrading enzymes, and (iii) assess whether prokaryotic collagenases degrade the ECM of cells in the fetal membranes directly, or indirectly through the activation or stimulation eukaryotic MMP expression.</p>
19	Anderson, Carolyn	Chemistry & Biochemistry	1	<p>Organic Chemistry: Rearrangement of Propargyloxypyridines to N-Substituted Pyridones</p> <p>Organic synthesis is a powerful technique that allows access to a wide range of different structural motifs. In this project, we are working to develop a method for the synthesis of N-substituted pyridones; an interesting functional group found in a series of pharmacologically interesting compounds. To date, we have developed an experimental method for accessing this motif by rearranging a related system. The student working in this area will be responsible for preparing and testing additional substrates in the rearrangement and for optimizing this reaction to give the desired products. The student will gain experience with synthetic organic chemistry techniques, including: running reactions, purification, organic spectroscopy, and experimental design.</p>
20	Anderson, Carolyn	Chemistry & Biochemistry	2	<p>Organic Chemistry: Synthesis of N-Alkyl Pyridone Containing β- and γ-Amino Acids</p> <p>Organic synthesis is a powerful technique that allows access to a wide range of different structural motifs. In this project, we are working to develop a method for the synthesis of N-alkyl pyridone containing β- and γ-amino acids – homologues of the natural amino acids, which contain an interesting functional group found in a series of pharmacologically active compounds. To date, we have discovered an important intermediate in route to these species and have begun to optimize its synthesis. The students working in this area will continue to seek conditions for the preparation of this intermediate and its conversion into the desired amino acids. The students will gain experience with synthetic organic chemistry techniques, including: running reactions, purification, organic spectroscopy, and experimental design.</p>

21	Arnoys, Eric	Chemistry & Biochemistry	1	Diffusion and Transport of Galectin-3 We will examine the rates of diffusion and nuclear transport of the splicing factor galectin-3 in polarized cells and use kinetic and mathematical models to derive quantitative comparisons of its behavior with other proteins. We will also determine whether it interacts directly with specific transport proteins. These comparisons will help us better understand the workings of the cell and may yield insight into the molecular basis of specific diseases.
22	Arnoys, Eric	Chemistry & Biochemistry	2	Watching Proteins in Real Time We will characterize the behavior of several proteins in living cells with state-of-the-art techniques to examine their cellular localization, mobility, and interactions with other proteins. We will also make large amounts of these proteins in bacteria so that we can compare their ligand binding.
23	Blankespoor, Ron	Chemistry & Biochemistry	1	Rhodium-Catalyzed, Allylic Substitution Reactions One part of this project will be a mechanistic study in which a series of aryl-substituted, allyl carbonates, previously prepared in our laboratory, are reacted with benzylamine in the presence of a rhodium catalyst. These carbonates, which contain a phenyl group substituted with a variety of different groups at the para position, will be reacted under identical conditions to determine how the substituents impact the rate and enantioselectivity of the reaction. Another part of this project will focus on the scope of this rhodium-catalyzed, allylic substitution reaction. Leaving groups such as chloride, trifluoroacetate, and acetate will be examined along with a variety of good nucleophiles. This project will be done in collaboration with a Pfizer laboratory in Ann Arbor, which is providing some of the funding for the project. The goal of this work is to provide another synthetic tool for making drugs that are composed of a single substance, thereby making them safer and more effective in their applications.
24	Benson, David	Chemistry & Biochemistry	1	Discovering Tyrosine-Cysteine Crosslinks in Hemoglobin Hemoglobin will be modified using peroxidase chemistry. The student will purify hemoglobin and monitor reaction products from peroxidation reactions. Analysis will involve UV-visible, fluorescence and HPLC analysis. It is possible that synthetic analogues from Prof. Tatko's laboratory will be examined as well.
25	Benson, David	Chemistry & Biochemistry	1	Nanoparticle Biosensors: Automated Analysis of Single Nanoparticle Fluorescence Movies Data for this project has been/will be generated from single semiconductor nanoparticles (quantum dots) attached to glass surfaces and measured with a high-sensitivity fluorescence microscope. The researcher will optimize existing code in LabView, IDL, MatLab, and IgorPro to perform this analysis. Secondly, the researcher will incorporate code from these packages into a single platform package using Python.
26	Benson, David	Chemistry & Biochemistry	2	Nanoparticle Biosensors: Single Maltose Biosensor Observation This project involves protein purification and modification along with manipulation of semiconductor nanoparticles (called quantum dots). Modified proteins will be attached to quantum dots to generate samples that change emission intensity as the concentration of only maltose is added to the solution. These reagents will be attached to glass surfaces under dilute concentrations and the glass surface fluorescence will be measured with a high-sensitivity fluorescence microscope. Single biosensors will be isolated from movie images by software and examined by the researcher.
27	Benson, David	Chemistry & Biochemistry	2	Nanoparticle Biosensors: Maltose Biosensor Validation This project involves protein purification and modification along with manipulation of semiconductor nanoparticles (called quantum dots). Modified proteins will be attached to quantum dots to generate samples that change emission intensity as the concentration of only maltose is added to the solution. The maltose-dependent response has been previously reported, but the ability to use these reagents in maltose detection will be tested. Specifically, these reagents will be attached to glass surfaces the glass surface fluorescence will be measured with the addition of maltose in a variety of matrices.

28	DeKock, Roger	Chemistry & Biochemistry	1	Sites of Protonation and Ligand Migration in Bimetallic Organometallic Complexes We plan to examine sites of protonation and ligand migration in bimetallic organometallic complexes by means of computational chemistry. The systems that we plan to study include the metals Ru, Rh, Os, and Ir. We are interested, among other things, in migration of a bridging hydride ligand to react with a bridging methylene ligand. The result of this reaction is to form an agostically bonded methyl group. We want to know if this migration takes place by a transition between the two metal atoms, or by some other means. We employ electronic structure theoretical methods to examine the different possibilities.
29	DeKock, Roger	Chemistry & Biochemistry	1	Cooperativity in Hydrogen Bonding We examine cooperativity in hydrogen bonding by means of computational chemistry. Specifically we employ electronic structure theoretical methods. The systems that plan to study include small arrays of water molecules with one or more solute molecules embedded in the array. Examples of solute molecules include ammonia, hydrochloric acid, hydrofluoric acid, and carbon dioxide.
30	Louters, Larry	Chemistry & Biochemistry	1	Effects of Cinnamaldehyde on Glucose Uptake Cinnamaldehyde activates glucose uptake under basal conditions, but strongly inhibits activation of glucose uptake under cell stress conditions such as glucose deprivation. The project explores the mechanism of this behavior in an attempt to better understand the glucose transport activity of GLUT1.
31	Louters, Larry	Chemistry & Biochemistry	1	Effects of the hypertensive drug, verapamil, on glucose uptake in insulin sensitive cells Patients who have overdosed on verapamil (a calcium channel blocker normally prescribed for hypertension) have severely compromised glucose uptake. These patients can be rescued by administering insulin. It appears that muscle cells, especially cardiac cells are particularly sensitive. This project explores the effects of verapamil and insulin on glucose uptake in cultured muscle cardiac cells.
32	McCarthy, Darla	Chemistry & Biochemistry	1	Characterization of Tetrachlorohydroquinone Dehalogenase in Mycobacterium chlorophenolicum We will identify the cofactor(s) involved in the dechlorination of tetrachlorohydroquinone (TCHQ) by TCHQ dehalogenase in Mycobacterium chlorophenolicum. M. chlorophenolicum is a soil microbe that degrades pentachlorophenol (PCP), a persistent and toxic environmental pollutant. An intermediate step in the metabolism of PCP is catalyzed by TCHQ dehalogenase. Past efforts at isolating and characterizing TCHQ dehalogenase have been hampered by the loss of enzyme activity during the isolation process, presumably due to the loss of an as-yet-unidentified cofactor or cofactors. We will attempt to reconstitute enzyme activity by the addition of various possible metal cofactors, as well as by addition of mycothiol, a bacterial reducing agent which we will purify from mycobacterial cells.
33	Muyskens, Mark	Chemistry & Biochemistry	1	Fluorescence in Narra Wood The goal of this project is to investigate the chemical structure of the highly fluorescent components of the aqueous extract of narra wood. These compounds have historical significance, but the added complexity that they are pH dependent structures. The work involves liquid chromatography for separation and fluorescence spectroscopy.
34	Muyskens, Mark	Chemistry & Biochemistry	1	Laser photochemistry of fluorinated acetylacetone The goal of this project is to study the effect of collisions to deactivate laser-excited fluorinated acetylacetone molecules. The unique photochemistry forms a ring structure from a linear molecule in the gas phase. We observe the efficiency of the reaction by measuring the amount of photoproduct using IR spectroscopy after laser excitation. Introducing mixtures of acetylacetone with inert gases will reveal the extent to which the partner gas can effectively quench the reaction process.

35	Sinniah, Kumar	Chemistry & Biochemistry	2	A Single Molecule Approach to Studying Human Telomere G-Quadruplex DNA Guanine (G) quadruplexes are a family of nucleic acid structures where four guanine bases from one, two or four G-rich DNA strands can form a planar quartet stabilized by hydrogen bonding and by monovalent cations. Quadruplexes play an important role in human telomeres and promoter regions of genes. The anticancer potential of quadruplexes is in part due to the formation of DNA quadruplexes in telomeres, where such structures inhibit the activity of telomerase, an enzyme expressed selectively in cancer cells. The loss of telomerase activity causes cancer cells to lose the ability to divide leading to cell death. Recent studies have focused on the topology of quadruplexes yet there is very little understanding of the physical properties of these unusual DNA structures. In this study, we will design DNA sequences that generate bimolecular G-quadruplexes and examine its stability using single molecule techniques such as atomic force microscopy along with bulk measurements obtained from differential scanning calorimetry.
36	Sinniah, Kumar	Chemistry & Biochemistry	1	Insulin and Anti-Cancer Drug Interaction with G-Quadruplex DNA The ends of chromosomes are called telomeres and they are important for gene stability. The presence of guanine (G) quadruplexes in human telomeres and gene promoters is of significant interest. Stabilizing G-quadruplexes result in cells to lose their ability to divide, resulting in cell death. As such G-quadruplexes are attractive targets for cancer therapeutics. Furthermore, recent studies show that G-quadruplexes are also capable of capturing insulin which suggests that there might be a possible role of G-quadruplex formation in the regulation of transcription of the insulin gene. In this study, we will design DNA sequences that mimic the human insulin gene promoter region and the human telomere region. Each of these DNA sequences will be used for forming a G-quadruplex and drug interaction with the quadruplex will be studied using single molecule based methods.
37	Tatko, Chad	Chemistry & Biochemistry	1	Biocatalytic Desulfurization of Diesel Fuel Sulfur combustion in fuels contributes to acid rain generation and cardiopulmonary disease. Recently efforts to remove recalcitrant sulfur have not been successful. Using peptide scaffolds to bind DBT (dibenzothiophene) may afford a reasonable method for oxidation and subsequent desulfurization.
38	Tatko, Chad	Chemistry & Biochemistry	1	Manipulation of Tyr's pKa Through Noncovalent Interactions The active site of GST contains a Tyr with a pKa highly deviant from normal. This unusual pKa is essential for protein function. A peptide model of this system will be used to explore the fundamental forces responsible for this change and its electronic susceptibility.
39	Tatko, Chad	Chemistry & Biochemistry	1	Tyr-Cys Crosslinks in Beta-Hairpin Peptides Posttranslation modifications of proteins, such as Tyr-Cys crosslinks are difficult to study due to their low incidence. Synthetic generation of model systems is an efficient method to study these crosslinks. Peptide models will be used to determine the structure and environment to obtain and explore these synthons.
40	Vander Griend, Douglas	Chemistry & Biochemistry	1	Heavy Metals and Bacterial Biofilm Formation Bacteria that exist in communities called biofilms are more resistant to antimicrobial agents than free-swimming counterparts. Although it has been shown that extracellular substances associated with biofilms are able to adsorb heavy metals, less is known about how heavy metals influence the formation of biofilms. Students will measure biofilm formation in the presence of heavy metal ions. In addition, students will study heavy metal sensitivity, biofilm formation, and gene regulation in a <i>S. aureus</i> strain which has a mutation in the <i>cadC</i> gene, a regulatory gene within a cadmium-resistance operon. This work will contribute to a better understanding of how biofilm bacteria are able to resist antimicrobial agents and cause diverse problems such as the biofouling of pipes and recalcitrant medical infections. This project is carried out in conjunction with Prof. Hoogewerf of the Biology Department.

41	Vander Griend, Douglas	Chemistry & Biochemistry	2	Nanomolecular Building Projects with Spectrophotometric Characterization via Factor Analysis Understanding and controlling the synthesis of supramolecules is a key goal of nanotechnology. The student working on this project will use UV-vis spectroscopy to investigate the solution chemistry of nickel(II) and copper(I) cations, which typically bind to four molecules. Composite data is measured which is then modeled via equilibrium-restricted factor analysis, a mathematical technique for studying specific chemical species while they interact in an equilibrium mixture. A significant element of the research involves collaboration with a graduate lab at Indiana University, and with an industrial lab at Pleotint, LLC.
42	Adams, Joel Vander Linden, Keith	Computer Science	1	Two-Person Immersive 3D Virtual Reality in Java In summer 2008, Jess Vriesma built a C++ class library of primitive virtual reality objects. This project is to build on that 2008 work by: (i) defining a similar virtual reality class library in Java; and (ii) extending that class library so that multiple people can interact in VR simultaneously. This approach will make virtual reality a social experience, in which two people can interact with one another and their 3D surroundings. The Java library will make it possible for freshmen in Prof. Keith VanderLinden's CS 108 course to create immersive 3D VR environments. The resulting pool of students will be capable of building 3D visualizations for future science division research projects.
43	Plantinga, Harry	Computer Science	1	Similarity measures and search algorithms for musical scores Similarity measures and search databases are used for a variety of purposes. For written text and for computer programs they are used for plagiarism detection. In biology they are used for recombining genetic sequence fragments and searching for similarities in genetic data. We propose to develop similarity measures and search algorithms for finding similarities in musical scores. These similarities would be useful for a number of purposes. Plagiarism in music is an important area that has resulted in numerous lawsuits. In addition, a similarity measure could be used to track changes to music such as a hymn tune over the years if it is published in many different editions. Finally, a similarity measure and detection algorithm could be used to power a search engine for musical themes that are typed or hummed into an engine. This project will involve researching similarity measures and detection algorithms for music and implementing them. The Hymnary.org website project has a large collection of scores that can be used for building and testing the database and search engine. With a similarity algorithm able to find discrepancies between different versions of the same musical piece, it will be possible to trace the ancestral tree of variants of the piece of music.
44	Vander Linden, Keith	Computer Science	1	A Minimalist Educational Companion for the Calvin Ecosystem Preserve Educational materials tend to be print-based, pre-scripted, and tied to a classroom. They favor students who read and write quickly, follow instructions well, and are able to sit and focus for extended periods of time in classrooms. While this mode of instruction has its place, we would like to assemble a technical infrastructure that supports active, emergent materials that are targeted at broader mobile spaces. We expect this infrastructure to engage new audiences in new ways. We propose to build an Android application and supporting backend server that can provide supporting materials to students exploring larger mobile spaces. The application will allow instructors to create basic educational objectives and supporting materials in advance, and then will allow students to access and extend those materials using the client interface. The infrastructure would be generally appropriate for any constituency in any geographically distributed space, say a virtual museum, national park or college campus. We will build our prototype application for visitors to the Calvin College ecosystem preserve. The application will be developed in collaboration with faculty members from the departments of computing (Jeff Nyhoff & Keith Vander

45	Si, April X.	Engineering	1	<p>The study of anti-scale by surface modification of the heat exchanger surfaces The scale deposition on heat transfer surfaces from water containing dissolved salts reduces the efficiency of heat transfer and performance of the equipment considerably. How to reduce the scale deposition onto the surface becomes into a critical point of the study. Different materials have different surface tension, higher surface tension will attract more particles. To reduce the surface energy of the metal surfaces is an important way to reduce scale deposition.</p> <p>There are several ways to reduce the surface energy of the metals. There are physically polished surfaces and chemically modified surfaces by PTFE films and SAMs(self-assembly monolayers). This study will answer which one is more efficiently reduce the scale deposition and which one will be the most stable surface and how efficient the modified surfaces compared with the unmodified surfaces.</p>
46	Sykes, Aubrey	Engineering	1	<p>The Limits of Recycling Technology Effective and efficient recycling is one key to approaching sustainability. However, recycling is currently limited by significant technological challenges. The aim of this project is to devolve these into a systematic organization that identified the current leaders in the different recycling arenas, the technology deployed and the challenges to creating improved technologies. The idea is to develop a framework from which a guidebook of recycling technology and its challenges could later be developed.</p>
47	Sykes, Aubrey	Engineering	1	<p>Design of the Raybrook-Calvin Bridge Three years ago, Woodlawn CRC (which meets in the Calvin College Chapel) built its Ministry Center on the College's property between Raybrook and Calvin's Main Entrance (on Burton Street). Now, Calvin's property and Raybrook are separated by a small rivulet of Whisky Creek in a gulch. A project is proposed to design a personnel bridge (no-auto traffic), including approaches from both directions, joining these two properties. This bridge would be used for the foot traffic that currently traffics between Raybrook/the apartment complex/Woodland Mall by way of Raybrook Street, SE. As Whisky Creek is an ecological area, this project will require careful attention to the effect of the bridge's construction and use.</p>
48	Wunder, David	Engineering	1	<p>Water Treatment Properties of Bagasses Charcoal This work focuses on the investigation of the water treatment properties of bagasse charcoal. Charcoal is widely used in developing global regions as a residential fuel source for heating and cooking, and is typically derived from trees, with concerns of deforestation associated with this practice. Bagasse, in contrast is a readily renewable “waste” byproduct of sugarcane processing. This research will focus on the water treatment properties of bagasse charcoal, and will use mathematical models to describe relevant contaminant removal processes (e.g., sorption isotherms, clean-bed filtration theory, etc.)</p>
49	Bascom, Johnathan	Geology, Geography & Environmental Studies	1	<p>An Atlas of Eritrea. This map collection will accompany A Geography of Eritrea, a book written by Professor Bascom, which is approaching completion. However, substantial work on an atlas of maps and other graphics to illustrate the book is still needed. This atlas is for the newest country in Africa. No such atlas exists. It will be used for a geography course on Eritrea, required of all students at the national university. A Geography of Eritrea – and its atlas developed via this project – will serve as the primary reference for teachers at primary and secondary schools throughout Eritrea too. It also will be of interest to relief agencies doing development work, academic audiences at large, and Eritreans who now reside outside the country.</p>
50	van Dijk, Deanna	Geology, Geography & Environmental Studies	2	<p>Lake Michigan Coastal Dune Features Inventory This project studies the contemporary geomorphology, human impacts and management of Lake Michigan coastal dunes in Ottawa and Muskegon counties. A systematic system for recording dune characteristics—the Dune Features Inventory (DFI) checklist—will be applied to a variety of dune sites through site visits, air photo analysis, and literature reviews. Collected data will be analyzed to determine patterns including the range of geomorphic characteristics, levels of human impacts, and presence of management practices.</p>

51	Bolt, Michael	Mathematics & Statistics	2	Numerical conformal mapping and potential theory in the plane A conformal map is a map from the plane to itself that preserves angles. A famous theorem of Bernhard Riemann from 1851 says there is essentially one conformal map between simply connected domains. The problem is how to compute this map along with other potential theoretic objects in the plane. We will adapt a method of Norberto Kerzman and Elias Stein from the 1970's in order to handle the case of a multiply connected domain. We will also extend their method to the situation when the boundary is described using only a finite set of points and to the situation when the boundary has corners. An important aspect of the project will be the visualization of various mathematical structures.
52	Bolt, Michael	Mathematics & Statistics	2	Beckman-Quarles theorems and characterizations of maps The first aspect of the project will be to establish a Beckman-Quarles theorem for distance functions in geometries that arise by enlarging the Euclidean symmetry group to include dilations and inversions. (The usual distance between points no longer makes sense--one needs a new notion of distance and a new notion of point!) The original Beckman-Quarles theorem says that a mapping of Euclidean space that preserves pairs of points a fixed unit distance apart must be a rigid motion. A second aspect of the project will be to characterize maps in terms of distance functions.
53	Kapitula, Todd	Mathematics & Statistics	2	Dynamics of Matter Waves in Bose-Einstein Condensates The dynamics of matter waves in Bose-Einstein condensates is modeled by the Gross-Pitaevski equation, which is a variant of the famed integrable nonlinear Schrodinger equation. While the equation is easy to write down, it is unfortunately infinite-dimensional. We will explore different physical and mathematical mechanisms which allow us to safely reduce the system to one which is finite-dimensional. We will then explore the dynamics associated with the smaller system. Finally, in order to validate the reductions we will compare the results and insights derived from the smaller system with that which is seen for the full system.
	Moseley, Chris	Mathematics & Statistics		see Project #60
54	Haan, Stan	Physics & Astronomy	4	Computer modeling of laser double ionization of atoms Students will participate in an ongoing project in theoretical physics investigating the mechanism(s) by which lasers with visible or infrared wavelengths remove two electrons from atoms. Both classical and quantum mechanical modeling have been employed, and a given student may be involved with either or both, depending on student interest and background. The project involves extensive computer work, and some programming experience is desirable but not essential. Ideally, one student will work on adapting the program and analysis packages to use the new supercomputer. Every student involved can reasonably expect to coauthor a professional publication.
55	Haarsma, Deborah	Physics & Astronomy	1-2	The Puzzling Centers of Galaxy Clusters In a galaxy cluster, the space between the galaxies is filled with very hot gas which emits X-rays. At the center, the gas is denser and can radiate quickly enough to cool off and form a "cool core." In this project, the student(s) will investigate the Brightest Cluster Galaxies (BCGs) in several clusters and their relationship to cool cores.
56	Haarsma, Loren	Physics & Astronomy	1	Investigation of type and function of ion channels in duct cells of the lacrimal gland Lacrimal glands supply tear fluid, and the duct cells appear to secrete potassium to increase the [K+] concentration of tears. We will do electrophysiology experiments on lacrimal gland duct cells, characterizing the potassium and chloride ion channels in their cell membranes, to investigate the mechanisms of potassium secretion. This is relevant to dry eye disease and the health of eye surfaces.

57	Harper, Paul	Physics & Astronomy	1-2	Optical and Simulation Studies of Lipid Phase Transitions Lipid phase transitions are highly relevant to understanding the behavior of membrane proteins and the cellular processes of pore formation, division, fusion, and infection. The static phase transition temperatures have been extensively studied, but, relatively speaking, the kinetics have received little attention. Last summer, we found that lipids with saturated tails exhibited much faster kinetics than lipids with unsaturated tails; this summer we will optically probe the effect of salt concentrations and, potentially, anti-microbial peptides on lipid kinetics. Concurrent with the laboratory work, we will also utilize Calvin's new Beowulf cluster to make ultra-coarse grain simulations of pore formation in lipid membranes.
59	Jadrich, Jim	Physics & Astronomy	2	The Development of Scientific Reasoning Skills and Strategies & Investigation of a Paradigm Shift in Science Teacher Education This summer research project is divided into two parts, corresponding to the completion of one NSF-funded project (The Development of Scientific Reasoning Skills and Strategies) and the beginning of a second NSF-funded project that is a supplement to the first (Investigation of a Paradigm Shift in Science Teacher Education). The first project is the culmination of a three-year study that investigates 1) A hierarchy, both in terms of efficacy and sophistication, of scientific reasoning strategies utilized by both experts and novices when confronted with tasks dependent upon integrated scientific process skills, and 2) a comparison of the differences in reasoning strategies utilized by a comparison group and an experimental group having received specific scaffolding interventions. The second project is a study of the effects of an informal learning experience on pre-service science teachers understanding and implementation of inquiry-based science in the context of a teacher education program modeled on the learning cycle approach.
60	Molnar, Larry Moseley, Chris	Physics & Astronomy	2	Dynamics of Asteroids To a remarkable degree, the history of our solar system is recorded in the details of the orbits of the numerous small bodies that are left over: the asteroids. In last summer's research project we used a newly developed technique to work out the history of the inner edge of the asteroid belt. Analysis of extensive observations with our Rehoboth telescope have born out our initial hypothesis of a catastrophic collision of the asteroid Flora 500 million years ago. The principle tasks for this summer will be 1) to begin followup telescopic observations on the asteroids studied in the first phase of the project; 2) to develop analysis techniques that can use the multiyear asteroid data to determine fully the orientation of the spin axis of each asteroid; 3) to interpret this more complete spin information as a more complete history of the inner belt; and 4) to begin computational simulations of the history of another asteroid collision further out in the belt. This work is part of an interdisciplinary project being done with Prof. Moseley of the mathematics department.
61	Walhout, Matt	Physics & Astronomy	1	Spectroscopic study of long-range krypton molecules The student will continue an ongoing effort to produce and characterize an unusual type of molecule, in which two krypton atoms are bound together by a long-range force that reaches far beyond the size of the atomic electron distribution.
62	Moes, Paul	Psychology	1	Investigation of possible neuronal function for Probsts bundles Agenesis of the corpus callosum (ACC) is a congenital defect. In some human and animal types, neuronal fibers which ordinarily would cross the midline during fetal development instead run in a rostral-to-caudal direction and terminate in the ipsilateral cortex, forming Probsts bundles (PB). We will first learn how to remove, preserve, and section rat brain tissue and prepare those tissue slices for electrophysiology experiments. We will then study brain slices from a mouse strain which consistently develop PB fibers to determine if these axons conduct action potentials and if the fibers become functional GABAergic neurons.

