

BEE Research Symposium Abstract Book

February 27, 2009

(abstracts for presentations and posters begin on page 2)

1st Presentation Session	Riley Robb 125	10:00 – 11:30AM
--	-----------------------	------------------------

10:00*Ben Gray – Ahner Lab*

Cellulolytic enzyme expression in tobacco chloroplasts

10:15*Matt Agler – Angenent Lab*

Undefined, mixed microbial cultures for production of butyric acid from corn fiber

10:30*Rodrigo Labatut – Scott Lab*

Anaerobic degradability of complex materials

10:45*Vineet Rakesh – Datta Lab*

Transport in deformable porous media: Applications to biomaterials processing

11:00*John Connelly – Baeumner Lab*

Electrochemical microfluidic biosensors for the detection of enteric viruses from environmental waters

11:15*Sarah Munro – Walker Lab*

The fermentation stoichiometry of *Thermotoga neapolitana* and effects of environmental parameters on biological hydrogen production

1st Poster Session	Riley Robb 400	11:30AM – 1:00PM
--------------------------------------	-----------------------	-------------------------

2nd Presentation Session	Riley Robb 125	1:00 – 2:00PM
--	-----------------------	----------------------

1:00*Helen Dahlke – Soil and Water Lab*

Forecast of spatially distributed runoff dynamics in the Finger Lakes region using an interactive web tool and Python

1:15*Maria Vicenta Valdivia – Soil and Water Lab*

The role of microbial processes in soil phosphorus dynamics

1:30*Joanna Krzyspiak – March Lab*

Recreating in vivo epithelial behavior using stem cells in a microfluidic platform

1:45*Thua Tran – Luo Lab*

Engineered DNA as nanomaterials

2nd Poster Session	Riley Robb 400	2:00 – 3:00PM
--------------------------------------	-----------------------	----------------------

Biological and Environmental Engineering

Presentations:

Cellulolytic enzyme expression in tobacco chloroplasts

Ben N. Gray*, Beth A. Ahner

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: bng3@cornell.edu

Undefined, mixed microbial cultures for production of butyric acid from corn fiber

Matthew T. Agler^{1*}, Loren B. Iten², Michael A. Cotta²,
Bruce Dien², Largus T. Angenent¹

¹: Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

²: USDA/ARS, 1815 N. University St, Peoria, IL 61604

*: Presenter, e-mail: mta42@cornell.edu

Interest in renewable fuels from alternative feedstocks has magnified recently because of unpredictably fluctuating fuel prices and questions regarding the sustainability of fuel produced from potential food crops. We are studying the conversion of corn fiber, a byproduct in the corn-to-ethanol industry, into n-butyrate that can be utilized as a precursor for the biofuel butanol. The bioconversion process, which consists of anaerobic hydrolysis and fermentation, is performed with thermophilic (55°C) undefined mixed microbial cultures. To optimize bioconversion of the corn fiber, we compared three different methods of pretreatment with a nonpretreated control for its susceptibility to hydrolysis and subsequent fermentation. The three pretreatments were performed in fluidized sand bath reactors at 36% corn fiber w/v in water at 160°C for 20 min with the variations: 1. 0.5 % w/v H₂SO₄ (acid); 2. 1:10 CaO to biomass ratio (base); or 3. hot water only. Four identical 5-L anaerobic sequencing batch reactors (ASBRs), each fed one version of the substrate (diluted 4.8x), were operated at environmental conditions designed to maximize hydrolysis and n-butyrate production. Methanogenesis was inhibited by nitrates in the pretreated substrate and by maintaining the pH at 5.5. Volatile fatty acid production diverted toward n-butyrate after inhibition of hydrogenotrophic methanogenesis when hydrogen levels made NADH oxidation by H⁺ reduction unfavorable (this inhibition occurred when total volatile fatty acids reached ~8,500 mg as CH₃COOH/L at pH = 5.5). Thus far, we have achieved n-butyrate concentrations of 4.39, 2.64, and 2.77 g/L at total pyruvate equivalent concentrations of 17.76, 14.40, and 15.90 g/L in reactors fed acid, base, and hot-water pretreated substrates, respectively. The reactor being fed untreated substrate reached n-butyrate levels of 2.42 g/L before subsequent failure due to biomass crowding. Additionally, we have shown that acetate, ethanol, and caproate are significant sinks for electron equivalents in the reactors. Thermodynamic analysis confirms several competing pathways to these products are viable (negative ΔG), and presents itself as a method to model the effects of environmental changes.

Biological and Environmental Engineering

Anaerobic degradability of complex materials

Rodrigo Labatut*, Norman R. Scott
Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: ral32@cornell.edu

Transport in deformable porous media: Applications to biomaterials processing

Vineet Rakesh*, Ashim K. Datta
Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: vr46@cornell.edu

Fundamental physics-based modeling with relevant experiments provides an effective framework to study a variety of transport processes in porous media with applications to food processing. The talk will include the development of a multiphase porous media model coupled with electromagnetics and solid mechanics to study and optimize several food processes such as deep fat frying, contact heating of meat, microwave combination heating and microwave puffing. The food materials heated during the processes were modeled as a rigid or deformable porous medium. The porous medium consists of multiple phases and modes of transport. The model included three different phases: solid matrix, water and gas (water vapor and air), and considered pressure driven flow, binary diffusion and phase change. The multiphase porous media model was coupled with electromagnetics for processes that included microwave heating. In certain food processes such as microwave puffing, significant structural changes in the material due to high pressure development are caused by phase change during rapid heating. The two-way coupling of multiphase porous media transport and deformation, which is critical to accurately simulate such processes, was also implemented. The results from computations were validated using different experimental techniques and analyzed to provide comprehensive understanding of the various processes and to thereby optimize the food processes.

Biological and Environmental Engineering

Electrochemical microfluidic biosensors for the detection of enteric viruses from environmental waters

John T. Connelly*, Antje J. Baeumner

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: jtc25@cornell.edu

Enteric viruses cause a multitude of human diseases, ranging from self-limiting gastroenteritis to the severe paralysis of poliomyelitis. Once infected, humans shed large numbers of virus particles in feces. Untreated or under-treated wastewater contaminating drinking and recreational waters lead to transmission of these viruses to others via the fecal-oral route. Current methods of detection are time-consuming and laboratory-based. Biosensors have been shown to be effective for the detection of low numbers of microorganisms and are rapid, sensitive, specific and portable. Specifically, electrochemical microfluidic biosensors have been developed previously in our lab which will be optimized for the detection of enteric viruses, focusing initially on feline calicivirus. This detection module will be integrated with a nanoporous membrane concentration module developed by Professor Brian Kirby's research group in Mechanical Engineering. The presentation will focus on the microfluidic electrochemical biosensor for virus detection with an overview of the overall micro-Total Analysis System that includes the micro-concentration module.

The fermentation stoichiometry of *Thermotoga neapolitana* and effects of environmental parameters on biological hydrogen production

Sarah A. Munro*, Larry P. Walker

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: sam68@cornell.edu

The hyperthermophilic bacterium, *Thermotoga neapolitana*, has potential for use in biological hydrogen (H₂) production. Batch experiments were conducted with *T. neapolitana* at temperatures of 60, 65, 70, 77, and 85 °C to determine the fermentation stoichiometry and influence of temperature on product yields and production rates. The overall stoichiometry for the conversion of glucose to fermentation products by *T. neapolitana* was 3.8 mol H₂, 2 mol CO₂, 1.8 mol acetate, and 0.1 mol lactate produced per mol of glucose consumed. Results from oxygen exposure experiments indicated that H₂ production did not increase under microaerobic conditions when compared to anaerobic conditions; this supports other evidence in the literature that *T. neapolitana* does not produce H₂ through microaerobic metabolism. It was also determined that glucose consumption was inhibited by a decrease in pH. When pH was adjusted by buffer addition *T. neapolitana* cultures completely consumed the available glucose.

Biological and Environmental Engineering

Forecast of spatially distributed runoff dynamics in the Finger Lakes region using an interactive web tool and Python

Helen E. Dahlke*, Tammo S. Steenhuis

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: hed23@cornell.edu

The role of microbial processes in soil phosphorus dynamics

Maria Vicenta Valdivia*, M. Todd Walter

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: mvv2@cornell.edu

Historically, several different mechanisms have been proposed to explain soil P transformations, which are strongly influenced by hydrology. Areas in the landscape prone to saturate and produce runoff may, therefore, become important P sources, as well as some strategies for controlling non point source (NPS) P pollution, such as Vegetated Filter Strips (VFSs). Recently, the discovery of numerous microbial processes potentially significant for P transformations has challenged the traditional abiotic perspective of P cycling. Their role has been investigated in this research. Particularly, the potential effects of three processes in P release were evaluated: the decay of soil microbial biomass, the activity of Polyphosphate Accumulating Organisms (PAOs) and dissimilatory iron (Fe) reduction. The experimental approach was divided in two parts. For the first one, undisturbed soil cores from a VFS receiving silage leachate were maintained under flooding and draining cycles with acetate and glucose as carbon (C) sources, followed by an aerobic P enrichment period in order to promote polyphosphate (polyP) storage by PAOs. P release during flooding was dominated by organic forms, confirming the contribution of the decay of soil microbial biomass. No polyP was found in the soils containing acetate following P enrichment, as revealed by liquid state ^{31}P Nuclear Magnetic Resonance Spectroscopy (^{31}P -NMR). This indicates that PAOs were indeed inactive, since their presence in the cores was confirmed later in the second part of this research. Fe reduction was observed in the cores containing glucose, supporting the microbial nature of this process, although no concomitant inorganic P (P_i) release occurred. In the second part of this research, the presence of known groups of PAOs and dissimilatory Fe reducers, i.e. *Accumulibacter* and *Geobacteraceae*, respectively, was determined in the field site and the soil cores from the first part of this research using Polymerase Chain Reaction (PCR) based techniques. Clone libraries were constructed for *Accumulibacter*, *Geobacteraceae* and total bacteria. They were also quantified using quantitative PCR (qPCR). The resulting spatial distribution patterns of *Accumulibacter* and *Geobacteraceae* in the study site constitutes important evidence of their potential role in soil P dynamics.

Biological and Environmental Engineering

Recreating in vivo epithelial behavior using stem cells in a microfluidic platform

Joanna Krzyspiak^{1*}, John C. March²

¹: Dept. of Biomedical Engineering, Cornell University, Weill Hall, Ithaca, NY 14850

²: Dept. of Biological and Environmental Engineering, Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: jek44@cornell.edu, address: Weill Hall, Ithaca, NY 14850

An essential component of gastrointestinal (GI) tract physiology is the microbial population that inhabits the lumen. Throughout the intestinal tract bacteria occupy specific niches and communicate with each other and with the epithelia surrounding them. The GI tract is responsible for the absorption of nutrients and drugs, thus there has been a continued effort to understand the interactions within the intestinal system and the affects various ingested factors have on the body. Studies of these interactions are difficult to perform in vivo as they require well-controlled conditions and temporal sampling. Further, high throughput kinetic and pharmacologic experiments are very expensive to carry out in vivo. In order to study interactions between microflora and epithelia and between drugs and the body, we are developing 3D microfluidic cell culture models of intestinal space. Key to making these models is the culturing of intestinal epithelia that match very closely the actual epithelial cells in the GI tract. The best way to accomplish this goal is to grow epithelial stem cells in vitro and differentiate them into the four types of epithelial cells associated with villus structures in the lumen: enterocytes, goblet, Paneth and enteroendocrine. It has been reported that for differentiation to occur in rat intestinal epithelial cells (IEC-6), Cdx2 transcription factor along with HNF-4 α expression is needed for differentiation into enterocytes, along with their coculture with mesenchymal cells. Other studies demonstrated that the use of IEC cells cocultured with mesenchymal cells in vivo regenerated all four cell populations. It is our goal to achieve this differentiation in vitro with Cdx2-HNF-4 α IEC-6 cells and mesenchymal cells. Failure to produce desired cell lines will lead to further studies involving proven differentiating external factors as well as alternative expression factors.

Engineered DNA as nanomaterials

Thua N. N. Tran^{*}, MOBEL Lab Group, Dan Luo
Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850
*: Presenter, e-mail: tnt8@cornell.edu

Our lab's interest centers on molecular engineering DNA as a generic material. By taking advantages of the amazing chemical, physical, and biological properties of DNA and by utilizing a myriad of DNA manipulating enzymes, our group has created DNA-based nanobarcodes, gels, and nanoparticles (these are the three major research directions of our group). For examples, we have invented a novel target-driven polymerization process where polymers can only be synthesized in the presence of a pathogen (HIV) DNA. We have also created a DNA gel that can produce large amounts of proteins without any living cells. Furthermore, nanoparticle-based 1D-nanowires, 2D-superlattices, 3D-supracrystals and free-standing monolayer sheets have been achieved by using DNA as an organizer. These examples demonstrate that DNA is indeed a versatile, novel material building block and that we can create new materials via DNA with desired properties and real-world applications.

Biological and Environmental Engineering

Posters:

Distributed denitrification from hydrologically sensitive areas in northeastern agricultural landscapes

Todd R. Anderson*, M. Todd Walter

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: tra8@cornell.edu

Denitrification may be an important sink of anthropogenic nitrogen (N) in eastern US watersheds. Actual rates of denitrification, however, have been difficult to quantify and remain one of the critical unresolved N processes at the landscape scale. This incomplete understanding of denitrification hampers the development of new, more sustainable water quality protection strategies. We propose an interdisciplinary investigation of patterns of nitrate fluxes in agricultural landscapes, combining expertise in hydrology, soil microbial ecology, and aquatic biogeochemistry. Denitrification rates will be measured in situ along hydrologic flow paths and across gradients of hydro-periodicities, i.e., frequency and durations of saturated conditions. In situ denitrification measurements will be measured using the relatively new, isotope-based push-pull method. Hydrological fluxes will be quantified using standard geohydrologic approaches and hydro-periodicities will be estimated based on recent advances in quantifying indices of hydrological similarity in the Northeastern US.

Polyphosphate accumulating organisms and biogeochemical hotspots

Josephine Archibald^{1*}, M.Todd Walter

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: jaa78@cornell.edu

Despite extensive research, many of the processes that control phosphorus (P) movement from agricultural fields to streams and lakes are not well understood. This limits our ability to develop management strategies that will mediate P contamination of freshwater ecosystems and subsequent eutrophication. Recently, advances in molecular microbiology have allowed us to exploit microbial processes influencing P solubility in wastewater treatment. Central to this enhanced biological phosphorus removal in wastewater treatment plants is a relatively recently discovered microorganism, *Candidatus accumulibacter*, which takes-up P and stores it internally as polyphosphate under alternating aerobic and anaerobic conditions. Within the past few months we have discovered this organism in the natural environment and its role in P biogeochemistry is unclear. We speculate that it may function similarly in variable source areas, which experience cycles of saturation and desaturation, as it does in the anaerobic-aerobic cycles in a wastewater treatment plant. If so, there may be potential opportunities to realize similarly new perspectives and advancements in the watershed context as have been seen in wastewater technologies. Here we present some of our preliminary findings.

Biological and Environmental Engineering

The impact of dissolved organic matter on colloid transport in unsaturated soils

Veronica L. Morales*, Tammo S. Steenhuis
Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850
*: Presenter, e-mail: vlm8@cornell.edu

The transport of colloidal pathogens and colloid-contaminant complexes from soils rich in dissolved organic matter (DOM) is known to be much greater than originally suspected. This enhanced mobility is especially common when excessive amounts of manure are applied to agricultural lands under wet conditions, resulting too frequently in contaminated groundwater with *Cryptosporidium* and *Giardia*. Like the sensitivity of colloid transport to soil water chemistry, the polydispersivity, configuration and adsorption affinity of humic substances is also dictated by the solution's pH, salt concentration and organic matter concentration. Thus, changes in these parameters will greatly affect the system in the dissolved and suspended phase.

The objective of this study is to investigate the effect of dissolved organic matter on the transport of colloidal particles in unsaturated porous media. Specifically, the individual and combined contributions from humic and fulvic acids are explored in the presence and absence of calcium salts at various pH levels.

Do water quality BMPs work? Combined monitoring and modeling hold the answer

Zachary M. Easton*, Patricia Bishop, Tammo S. Steenhuis, M. Todd Walter
Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850
*: Presenter, e-mail: zme2@cornell.edu

Although water quality problems associated with agricultural non-point source (NPS) pollution have prompted the rapid and widespread adoption of a variety of so called "best management practices" (BMPs), it has proven difficult to assess their cumulative impacts and individual effectiveness in reducing NPS pollution at the watershed scale. In this project we combined long-term monitoring, paired-watershed analyses, and process-based watershed modeling to assess changes in dissolved phosphorus (DP) for a 160 ha catchment in the New York City Catskill water supply watersheds. The land use was a combination of forests and dairy farmland. A suite of BMPs were implemented in the mid-1990s aimed at reducing P loads. Using a nearby 86 ha forested watershed as a control site for a paired-watershed study, we found that the DP loads were reduced by 43% (+/-6%) and particulate P loads dropped by 29%. To assess the roles of individual BMPs in this reduction we used the Variable Source Loading Function (VSLF) model, a distributed watershed model and empirical relationships for DP concentrations in runoff based on on-site rain simulator experiments. The model analysis predicted a total reduction that was within 5% of the paired-watershed analysis and showed that the most effective BMPs were those that disassociated manure spreading and other P sources from areas prone to generating runoff, i.e., hydrologically sensitive areas. Interestingly, barnyard BMPs, which were generally the most expensive, appeared to have little impact on stream water quality. Unfortunately, because we cannot mechanistically model the processes that control particulate P across a whole watershed, the model was unable to make similar assessments of BMP impacts on particulate P. This body of work emphasizes demonstrates that combining both long-term monitoring and process-based modeling allows us to evaluate BMP effectiveness in the "living landscape" without necessarily establishing special research watersheds.

Biological and Environmental Engineering

The role of roadside ditch networks in short-circuiting natural hydrologic pathways: Implications for nonpoint source pollution transport

Brian Buchanan*, M. Todd Walter

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: bb386@cornell.edu

In the face of increasing urban development, global climate change and burgeoning population growth, proper conservation and protection of freshwater resources is paramount. Research has demonstrated that nonpoint source pollution (NPS) constitutes a critical threat to the water resources of the United States and, further, that agricultural operations are one of the largest NPS contributors. Recent studies have indicated that roadside ditch networks, ubiquitous in both rural and urban landscapes, intercept and shunt significant quantities of overland runoff and shallow groundwater from agricultural fields to stream systems. Unfortunately, the impact of these alterations to natural flow regimes, watershed hydrology, and water quality are not well understood.

This study examines the effect of road ditch networks on basin morphometry, watershed hydrology, and pollutant transport dynamics. Highlights from our preliminary findings will be presented along with a summary of appropriate management strategies.

Pore scale simulation of colloid transport

M. Ekrem Cakmak*, Tammo S. Steenhuis

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: mec68@cornell.edu

Mobile subsurface colloids have received considerable attention because the migration of colloids and colloid-contaminant complexes through the porous matrix substantially increase the risk of groundwater pollution. Little information about mechanisms for colloid transport and colloid filtration in unsaturated porous media is readily available. In this poster we use a finite element program COMSOL Multiphysics® to investigate the transport of colloids around solid grains and air bubbles in a porous matrix. The simulations of the colloid movement around the bubble showed that more colloids collided with the bubble (a slip boundary) than with the solid grain (a no slip boundary). The slip boundary condition resulted in high pore water velocity around the bubble compared with the no slip condition where the low velocities hindered diffusion to the solid grain. By varying the flux, we show that pore water velocity has a substantial effect on the deposition and transport paths of the colloids. In addition we present results of unsaturated porous medium simulations on colloid transport and deposition with assemblages of solid grain and air bubble collectors.

Biological and Environmental Engineering

Denitrification and nitrous oxide (N₂O) emissions and hydrologic patterns across a temperate grassland-forest-alfalfa landscape

Junran Li*, M. Todd Walter

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: jl2428@cornell.edu

Denitrification and associated emissions of trace gas such as N₂O have significant impacts on global climate change. At the landscape scale, denitrification is poorly understood and this limits our ability to develop strategies for protecting estuaries and controlling global warming. In summer 2008, field chamber experiment was set up in Cornell's Teach & Research Center along a soil wetness sequence across a grassland-forest-alfalfa landscape to measure denitrification rates and N₂O emissions. The wetness sequence has an approximate length of 725 m and a total relief of 50 m. The grassland has an average slope of 20% lying on uphill section of the wetness gradient, followed by a nearly horizontal patch of forest, and an alfalfa field with slight relief. Soil moisture content (both volumetric and gravimetric) was monitored regularly along the wetness gradient, and a variety of soil physio-chemical properties, including pH, texture, soil organic carbon, nitrate, and ammonium contents, were also measured. Emissions of N₂O and denitrification will be monitored bi-weekly when the snow melts during the late spring. These results will then be correlated with the patterns of hydrologic and soil physio-chemical properties to identify spatial and temporal patterns of denitrification and N₂O emission across the landscape.

Anaerobic digesters change the phosphorus leaching behavior of dairy manure

Rebecca D. Marjison*, Curt A. Gooch, M. Todd Walter

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: rdm95@cornell.edu

This study analyzed how anaerobic digestion of dairy manure might change the amount, form, and rate of phosphorus (P) leached by rainfall. Anaerobic digestion has become an increasingly popular manure management option because it generates energy, but little is known about the behavior of P when digested manure is applied to fields. We performed leaching experiments using simulated rainfall on digester influent (undigested manure) and effluent (digested manure) collected from a near-by dairy farm. We applied a previously developed manure-P leaching model to our experiments to quantify our observations. Overall, we found that dissolved P-leaching from digested and undigested manures were relatively similar to each other, especially when compared to previously published rates and amounts of dissolved P leached from fresh manure, i.e., manure from a dairy barn floor. Specifically, the P leached much more rapidly from undigested and digested manure than from fresh manure. We speculate that the key difference between the manures in this study and the fresh manure examined previously is the total solids content; fresh manure has a much higher solids content than the manure used in anaerobic digesters. Our findings suggest that field spreading of liquid manures may require some modifications to the traditional practices to prevent nonpoint P loading to streams and lakes.

The role of biofilms and curli in *Salmonella* transport through porous media

Anthony E. Salvucci*, Tammo S. Steenhuis

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: aes84@cornell.edu

Microbial pathogens, such as *Salmonella* and *E. coli*, are continually deposited in the environment and have been shown to contaminate the groundwater by leaching through the vadose zone. Therefore, understanding the mechanisms controlling the transport of these microbial pathogens through porous media is critical to protecting drinking water supplies. As previous research has shown, retention of microbial pathogens in porous media can be influenced by numerous biological factors. Consequently, this experiment specifically investigated the role of biofilm formation and curli production on the transport of environmental *Salmonella* through porous media. Environmental *Salmonella* strains used in the experiment were isolated from tile drains on dairy farms. In addition, two well-characterized *E. coli* strains with known high and low biofilm and curli producing capabilities were tested as controls alongside the *Salmonella* isolates throughout the experiment. The isolates were first assayed for their ability to form biofilms and produce curli, and then a subset of these isolates, representing range of high and low biofilm and curli formation capabilities, were simultaneously examined for transport characteristics through packed sand columns. Transport characteristics were tested for correlation with biofilm and curli-forming capabilities. Unlike the *E. coli* strains in which column retention correlated with biofilm formation and curli production, no obvious correlation between *Salmonella* phenotypes was observed. The results indicate that while transport of well-characterized laboratory *E. coli* strains can often be hindered by the presence of curli and biofilms, such assumptions are not fully representative of the behavior exhibited by environmental isolates of *Salmonella*.

Using nanotechnology to identify and characterize hydrological flowpaths in agricultural landscapes

Asha Sharma*, M. Todd Walter

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: ans62@cornell.edu

Applying the power of nanoscale technology to answer landscape-scale questions constitutes an exciting new frontier in science and engineering. In this project, we propose a possible method of reducing the "nonpoint" problem associated with nonpoint source (NPS) pollution, a problem that has hampered agricultural sustainability and water quality protection for decades. We are developing superparamagnetic polylactic acid (PLA) microspheres incorporating DNA "nanobarcodes" as potential tracers. The eventual goal of this project is to develop technologies for identifying and characterizing different flowpaths at field and watershed scales by using multiple sets of polymer microspheres, each coded with unique DNA sequences, of which there are essentially limitless combinations, i.e., many flowpaths can be uniquely coded. Our ultimate vision is to have the capacity of introducing microsphere-encapsulated DNA at different points in a watershed and collecting these microspheres elsewhere in the watershed; using quantitative, real-time polymerase chain reaction targeted at the specific DNA, we would be able to determine the hydrological linkages and transport times between the collection point(s) and the points of DNA introduction. The potential advantages of this nanotechnology strategy compared to conventional tracers are the elimination of background interferences, the ability to segregate superimposed flowpaths through the design of strictly unique DNA tracers and the biodegradability of the tracers. This presentation highlights recent advances, new challenges, and potential applications for this tracer technology.

Biological and Environmental Engineering

Integrating a water balance into the soil and water assessment tool model

Eric D. White*, Tammo S. Steenhuis

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: edw43@cornell.edu

The Soil Water Assessment Tool (SWAT) is a watershed model widely used to predict water quantity and quality under varying land use and water use regimes. To determine the respective amounts of infiltration and surface runoff, SWAT uses the popular Curve Number (CN). While appropriate for engineering design in temperate climates, the CN is less than ideal when used in monsoonal regions where rainfall is concentrated into distinct time periods. The CN methodology is based on the assumption that Hortonian flow is the driving force behind surface runoff production, a questionable assumption in many regions. In monsoonal climates water balance models generally capture the runoff generation processes and thus the flux water or transport of chemicals and sediments better than CN based models. In order to use SWAT in monsoonal climates, the CN routine to predict runoff was replaced with a simple water balance routine in the code base. To compare this new water balance based SWAT (SWAT-WB) to the original CN based SWAT (SWAT-CN), several watersheds in the headwaters of the Abay Blue Nile in Ethiopia were modeled at a daily time step. While long term, daily data is largely non-existent for portions of the Abay Blue Nile, data was available for one 1,270 km² subbasin of the Lake Tana watershed, northeast of Bahir Dar, Ethiopia, which was used to initialize both versions of SWAT. Prior to any calibration of the model, daily Nash-Sutcliffe model efficiencies improved from -0.05 to 0.39 for SWAT-CN and SWAT-WB, respectively. Following calibration of SWAT-WB, daily model efficiency improved to 0.73, indicating that SWAT can accurately model saturation-excess processes without using the Curve Number technique.

Quantification of capillary force acting on colloids in a three-phase model system of partially saturated porous media

Wei Zhang*, Larry D. Geohring

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: wz47@cornell.edu

Colloid transport in the vadose zone has gained increasing importance due to groundwater contamination with colloid-size pathogens and contaminants attached to colloids. Although colloid transport in saturated system is well understood, the presence of air phase in partially saturated zone poses an additional challenge for elucidating the mechanisms of the colloid transport. Capillary force that occurs when a colloid protrudes through water film around the grain or near air-water meniscus-solid interface has been identified as the major mechanism for colloid retention. Capillary force could be several orders of magnitude greater than the classic DLVO forces (Gao et al., 2008). Our current study investigates the effect of colloid surface properties, fluid chemistry, and film thickness on capillary force and associated meniscus configuration in a three-phase model system consisting of a particle protruding out of a water film. This study is contributing to the understanding on the colloid transport in partially saturated porous media at the pore-scale. Some preliminary findings were presented herein.

Biological and Environmental Engineering

A general framework for heat and mass transport in porous media with application to food processing

Amit Halder*, Ashim K. Datta

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: ah333@cornell.edu

Mathematical modeling of food processes

Ashish Dhall*, Ashim K. Datta

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: ad333@cornell.edu

Biological and Environmental Engineering

Transport process modeling in food and medicine

Vineet Rakesh*, Ashim K. Datta

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: vr46@cornell.edu

Engineering liposomes for CD4+ T-cell detection

Katie A. Edwards*, Katherine J. Meyers, Barbara L. Dunkelw, Antje J. Baeumner

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: kae24@cornell.edu

Targeted and controlled delivery of sensitive pharmaceutical compounds may be accomplished using liposomes via drug-encapsulation within their aqueous cores and antibody and PEG functionalization of lipid bilayers for site-specific delivery and increased circulation time, respectively. The wealth of liposome-cell interaction knowledge gained from drug delivery studies and our prior work using fluorescent dye-encapsulating liposomes as analytical reagents prompted our investigations of such liposomes towards cell detection for clinical diagnostics. Here, we sought to engineer liposomes to rely on a specific biorecognition event, rather than non-specific fusion with cell membranes. Streptavidin-conjugated sulforhodamine B-encapsulating liposomes were used to detect CD4 T-cells in a microtiter plate-based sandwich immunoassay. These liposomes recognized biotinylated anti-CD4 bound to CD4-cells captured by anti-CD3 immunomagnetic beads. This antibody pair is exploited in flow cytometry to confer specificity for CD4+ T-cells versus monocytes as only these cells express both CD3 and CD4 molecules. Non-specific binding of the liposomes themselves to CD4-cells and monocytes increased with mol% coverage of the carboxylated lipid N-glutaryl-DPPE. This lipid imparted a negative surface charge on the liposomes which prevented their aggregation and was needed for streptavidin conjugation. To overcome non-specific binding without significantly altering the lipid composition and conjugation chemistry, PEG-DPPE was included in the formulation with varied coverage (0.5-3.0 mol%) and chain length (MW 350-5000). Increases in both parameters increased the liposomes' zeta potential and decreased non-specific binding, likely due to a shielding effect on the negative charge by PEG-DSPE. The performance of the resulting formulation for CD4 cell detection is presented.

Biological and Environmental Engineering

Fabrication of a microfluidic device for mRNA amplification

Peter J. Asiello^{1*}, Sam R. Nugen¹, Ayten Kalfe², Antje J. Baeumner¹

¹: Dept. of Biological and Environmental Engineering, Cornell University, Riley-Robb Hall, Ithaca, NY 14850

²: University of Dortmund, Germany

*: Presenter, e-mail: pja9@cornell.edu

A method for the fabrication of a disposable polymer based microfluidic chip and its application for the isolation of eukaryotic mRNA at low concentrations with a total channel volume of 3.5 μ L is described. Reproduction of microfluidic devices inexpensively is essential in the development of disposable micro-total analysis systems (μ TAS). Silicon masters are traditionally used for hot embossing polymer channels, but their fragility makes them unsuitable for frequent and long term use. Thus, they do not serve well as templates for the rapid prototyping or production of polymer chips by hot embossing. Instead of silicon, we chose to use copper as the embossing template due to its excellent thermal and electroplating properties. Fabrication of the copper master consisted copper electroplating the raised microchannel structures and this master was used to hot emboss poly(methyl methacrylate) (PMMA) to create the microfluidic device. We found the copper master to be much more robust than silicon and it held up very well during embossing and de-embossing. In addition, we were able to reduce our PMMA embossing time from 20 minutes to 5 minutes due to the increased heat transfer of copper to the PMMA, which allowed the production of devices rapidly and inexpensively.

Cryptosporidium parvum, a protozoan parasite, was selected as the target organism due to its high infectivity and importance to public water supplies. Messenger RNA isolation from lysed *C. parvum* oocysts was achieved using paramagnetic oligo (dT)25 beads within the microfluidic channel incorporating a sawtooth microstructured design to aid in mixing. Following the on-chip isolation steps, the oligo (dT)25 beads were subjected to Nucleic Acid Sequenced Based Amplification (NASBA). The resulting amplicon was then visualized in an agarose gel. The chip was able to successfully isolate sufficient hsp70 mRNA from as few as five oocysts.

Current research is focused on creating a highly efficient polyamidoamine (PAMAM) dendrimer surface on PMMA suitable for immobilization of oligonucleotides. Dendrimer activated surfaces have thus far been shown as suitable for the immobilization of oligonucleotides and will allow the immobilization of oligonucleotides directly on the wall of the

microfluidic device. This would replace the use of magnetic oligo (dT)25 beads.

The isolation of mRNA is the first step toward the development of a micro-Total Analysis System (μ TAS) for *C. parvum*. Along with mRNA isolation, we are developing methods for on-chip mRNA amplification and detection on a single, disposable chip. The ability to isolate, amplify, and detect a sample on a single disposable chip will result in a micro-total analysis system for *C. parvum* that will be faster, less expensive, and easier to use than current laboratory methods and can be utilized in the field for on-site pathogen detection.

Biological and Environmental Engineering

Human pathogenic *Cryptosporidium* species bioanalytical detection system with single oocyst detection capability

John T. Connelly*, Antje J. Baeumner
Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850
*: Presenter, e-mail: jtc25@cornell.edu

A bioanalytical detection system for the specific detection of viable human pathogenic *Cryptosporidium* species, *C. parvum*, *C. hominis*, and *C. meleagridis* is described. Oocysts were isolated from water samples via immunomagnetic separation, mRNA extracted with oligo-dT magnetic beads, amplified using nucleic acid sequence-based amplification (NASBA) and then detected in a nucleic acid hybridization lateral flow assay. The amplified target sequence employed was *hsp70* mRNA, production of which is stimulated via a brief heat shock. The limit of detection for the described method was established at 1 oocysts using flow-cytometer counted samples. Only viable oocysts were detected, as confirmed using DAPI/PI staining. The detection system was challenged by detecting oocysts in the presence of high concentrations of common waterborne microorganisms and packed pellet material filtered from environmental water samples. Comparing the method to EPA Method 1622 for *C. parvum* detection, highly comparable results were obtained. Since the described detection system yields unambiguous results within 4 hours, it represents an ideal method to monitor the safety of drinking water.

Adhesive contact printing for PMMA and glass in biosensing microfluidic devices

Lauren Dugard*, Antje J. Baeumner
Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850
*: Presenter, e-mail: lnd6@cornell.edu

Research is being presented focusing on microfluidic biosensor fabrication. Specifically, a method for bonding poly(methyl methacrylate) (PMMA) and glass in microfluidic devices has been further developed through the use of UV curable adhesive and a contact printing method. This method involves spin coating an intermediate carrier with adhesive then stamping the adhesive layer onto a PMMA piece imprinted with microfluidic channels. This allows a thin layer of adhesive to selectively transfer to the PMMA without getting adhesive into the channels. The PMMA is then pressed to a piece of glass and the device is allowed to cure under UV light (254 nm) for 15-20min. The current adhesive of choice is Loctite 3211 Light Cure Adhesive. Optimum coverage and adhesive layer thickness were achieved through the use of toluene to lower the adhesive viscosity while retaining the adhesive properties.

Biological and Environmental Engineering

Surface Characterization of poly(methyl methacrylate) and Polystyrene for PEG grafting

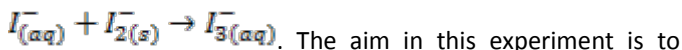
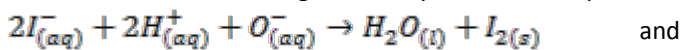
David N. Agyeman-Budu*, Peter J. Asiello, Sam R. Nugen, Antje J. Baeumner

Dept. of Biological and Environmental Engineering, Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: da76@cornell.edu

Microfluidic chips for the use in microbiosensors can be fabricated from a variety of polymer materials including polymers such as poly (methyl methacrylate) (PMMA) and polystyrene (PS). The choice of material influences fabrication and surface chemistries within the devices. PMMA is a popular choice by offering a host of fabrication techniques which range from hot embossing, imprinting, injection molding to laser ablation. Hence devices can be inexpensively made from PMMA which is very attractive for research in the areas of bioinstrumentation. The drawback however is that PMMA has a weak surface energy which makes it hydrophobic. This poses problems for the devices that they are made into because proteins and other biomolecules that are flown through these devices stick onto the surface walls of the PMMA device due to hydrophobic interaction.

A photochemical surface modification protocol of a piece of PMMA is explored which is aimed at creating a more hydrophilic surface onto which polyethylene glycol (PEG) can be grafted. This is achieved by treating the PMMA with UV radiation in the presence of O_3 that is created under the exposure chamber of a UV lamp. The oxidized PMMA generates free radicals. The radicals can be quantified with saturated sodium iodide which is reduced to iodine by the radicals. The amount of iodine is measured as the absorbance of the triiodide ion that is formed given by the equations:



The aim in this experiment is to achieve an optimal peroxide density on the PMMA surface for grafting with PEG chains. A surface BCA assay test is subsequently used quantify the amount of PEG.

Creating DNA-gold nanoparticle conjugates for lateral flow assays

Julie Leviter*, Antje J. Baeumner

Dept. of Biological and Environmental Engineering, Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: jl25@cornell.edu

A lateral flow assay (LFA) is being developed for the detection of DNA and RNA sequences for clinical diagnostics and the detection of pathogenic organisms. The LFA is a quick, inexpensive, and simple biosensor used to semi-quantitatively evaluate the presence of a target analyte. Such a system may consist of a membrane strip, an immobilized oligonucleotide sequence complementary to that of the analyte, the analyte itself, and a label that acts as a visual indication of the presence of the analyte. Previously, liposomes have been used as signaling means. However, their inability to be dehydrated on the membrane strips (Edwards et al, 2006) complicates the LFA procedure since liposomes need to be added as liquid reagent. An alternative is gold nanoparticles, which have a high stability and bio-compatibility, and can be easily attached to oligonucleotides or other biomolecules through strong thiol-Au bonds (Cai, 2001; Herdt, 2006). Here, we aim to optimize a procedure to conjugate oligonucleotides to colloidal gold such that it can be used as a label, and to compare their utility to that of dye-encapsulated liposomes. Initial experiments to detect atxA have resulted in a definite signal in the LFA. Future work will aim to increase binding efficiency and signal strength, by adjusting parameters such as temperature, pH, and ionic buffer strength.

Polymer biochips for nucleic acid electrochemical detection using liposomes

Sam R. Nugen*, Peter J. Asciello, John T. Connelly, Antje J. Baeumner

Dept. of Biological and Environmental Engineering, Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: srn6@cornell.edu

This paper discusses the design, microfabrication and use of an electrochemical biosensor based on a polymer substrate for cost effectiveness and disposability. As model analyte, amplified *hsp70* mRNA from *Cryptosporidium parvum* was chosen. Poly(methyl methacrylate) and polystyrene were investigated as substrates for the chips. UV surface modification of both polymers was characterized. The polymer surfaces were then conjugated with cystamine to improve gold adhesion properties. Cystamine surface densities were confirmed with an Ellman's reagent assay.

Microfluidic channels were fabricated using hot embossing with a copper master¹. The electrochemical transducer, an interdigitated ultramicroelectrode array (IDUA) was also realized directly on the polymer surface². Gold (200 nm) then evaporated onto the thiol functionalized surface. Using standard photolithography techniques, the IDUA containing 10 μm wide electrodes with 5 μm gaps was then formed followed by a gold etch. The polymer surface containing the microchannel was subsequently bonded to the polymer surface containing the IDUA using UV-assisted thermal bonding. The additional UV treatment also served to decrease the water contact angle of the surface from 62.5° to 48.4° and 84.3 to 24.8 for PMMA and PS, respectively. The *hsp70* mRNA was isolated from *C. parvum* oocysts and amplified using nucleic acid sequence-based amplification (NASBA). The amplicon was detected in a sandwich hybridization assay with capture probe-coated superparamagnetic beads and reporter probe-tagged liposomes. The liposomes entrapped potassium ferro/ferrihexacyanide to enable amperometric quantification of the amplicon on the IDUA. Amplicon from only 1 oocyst was detectable with this PMMA biosensor.

Modeling detection of *Cryptosporidium parvum* using electrochemiluminescence

Alexander D. Roth*, Sam R. Nugen, Peter J. Asciello, Antje J. Baeumner

Dept. of Biological and Environmental Engineering, Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: adr33@cornell.edu

Electrochemiluminescence (ECL) will be investigated for the use in a highly sensitive microfluidic biosensor for the detection of *Cryptosporidium parvum*. A ruthenium complex will be coupled to biotin. This complex will then be entrapped in liposomes. The liposomes, bearing a DNA probe that recognizes the *hsp70* mRNA of *C. parvum* will subsequently be used in a previously established microfluidic biosensor for *C. parvum* detection. Here, we present data on the coupling of ruthenium bis(hexafluorophosphate) ($\text{Ru}(\text{bpy})_2(\text{phen-5-NH}_2)(\text{PF}_6)_2$) to NHS-PEG₄-biotin which will subsequently be entrapped in liposomes. Also, data will be presented on the immobilization of streptavidin onto gold electrodes. Specifically, amine-functionalization of the gold is analyzed using an acid orange 7 assay, and streptavidin binding using a BCA assay.

Biological and Environmental Engineering

Physical properties of PEG-liposomes and their application in cardiac diagnostics

Yang Wang*, Antje J. Baeumner

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: yw242@cornell.edu

The effect of poly-ethylene glycol (PEG) chain length and percentage composition of PEG-liposomes were investigated by temperature stability analysis and zeta potential measurements. Both long term and short term stability studies suggest that increasing chain length and percentage coverage cause increased lysis of PEG-liposomes. Results from zeta potential measurements have shown that with increasing chain length and percentage coverage, the negative charges on the liposome surface, which prevent liposomes from aggregating and maintain the liposomes suspended in solution, are reduced. PEG-liposomes were used to quantify thrombin concentration in sandwich assays using two thrombin aptamers which bind to different sites on the thrombin molecule. A microtiter plate sandwich assay with a detection limit as low as 5nM was developed. Future research will focus on increasing the efficiency of the sandwich assay through optimizing the buffer, assay temperature and duration for the assay. Collectively, this research will contribute to an overall effort to characterize and optimize PEG-liposomes as signal transduction systems for biosensors and bioanalytical systems.

Investigating whole root systems: Root quantification tools and techniques

Randy T. Clark*, Daniel J. Aneshansley

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: rtc8@cornell.edu

Biological and Environmental Engineering

Characterization of phytochelatin synthase in *Thalassiosira pseudonana*

Tiffany L. Gupton*, Beth A. Ahner

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: tlg29@cornell.edu

Phytochelatins (PCs) are metal-binding proteins produced by plants, some yeasts and some algae in response to heavy metal stress. Phytochelatin synthase (PC synthase) is the enzyme responsible for synthesizing phytochelatin from a smaller peptide, glutathione (GSH). This enzyme has been targeted for phytoremediation research, a field that attempts to discover new ways to utilize plants for remediation of toxic sites. Understanding the functional characteristics of enzymes, like PC Synthase is key in an effort to make phytoremediation more effective and efficient. We have chosen to investigate a PC synthase from the marine diatom, *Thalassiosira pseudonana*, because previous studies suggest that this PC synthase may have novel characteristics when compared to PC synthases from other species. In vivo, *T. pseudonana* has been found to produce up to 80 times the concentration of PCs required for complexation of heavy metals when exposed to nanomolar concentrations of cadmium. We have isolated a PC synthase from *T. pseudonana*, called TpPCS3, via cloning, expression and immunoaffinity purification. Our *In vitro* assays that compare TpPCS3 to AtPCS1, a well studied PC synthase from *Arabidopsis thaliana*, suggest that TpPCS3 is more sensitive to oxidation than AtPCS1. In addition, TpPCS3 has a higher affinity for its substrate, Cd-GSH.

Modeling of the drying of astronaut cabin trash using a compartmentalized approach

JMR Apollo Arquiza*, Jean B. Hunter

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: jaa56@cornell.edu, address: Riley-Robb Hall, Ithaca, NY 14850

Biological and Environmental Engineering

Studying defined microbial cultures in continuous flow microbial fuel cells

Miriam Rosenbaum*, Largus Angenent

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: mr625@cornell.edu

A binary culture of *Lactococcus lactis* and *Shewanella oneidensis* was studied for an efficient conversion of glucose into electricity in a continuously-operated chemostatic electrochemical reactor. The homolactic fermentation bacterium *L. lactis* fermented glucose almost exclusively to lactate – the favourite electron donor for the electricigen *S. oneidensis*. The latter bacterium cannot utilize sugars directly as electron donor in microbial fuel cells. *L. lactis* alone showed no electrochemical activity, while the maximum obtained current density for *S. oneidensis* in a pure culture in lactate based medium was about 12 $\mu\text{A}/\text{cm}^2$, which confirms literature reports about this microorganism. However, in a binary culture with glucose as primary fuel, the current density increased by 140% to about 27 $\mu\text{A}/\text{cm}^2$. The study was followed using electrochemical, HPLC-analytical and electron microscopic techniques. The examination of the metabolic interactions between two defined species of microorganisms eventually will help to understand the complex food web among mixed bacterial communities in microbial fuel cells treating complex organic compounds.

In a second part of the study, *S. oneidensis* at an MFC anode was used to catalyze hydrogen gas production at the cathode in a process called biologically catalyzed electrolysis. Hydrogen production was followed volumetrically and with gas chromatography and hydrogen production yields and conversion efficiencies are presented.

Pseudomonas aeruginosa in a microbial fuel cell: A characterization of mutants

Arvind Venkataraman*, Largus Angenent

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: av299@cornell.edu

Pseudomonas aeruginosa, known for its pathogenicity, is also able to function as an electricigen in a Microbial Fuel Cell (MFC) because it produces phenazine compounds, which act as redox shuttles. Six single gene loss-of-function mutant strains and a wildtype strain of *Pseudomonas aeruginosa* were investigated for their electroactive properties in three different growth media under batch conditions. The mutants are deficient in the pathway for phenazine production (i.e., ΔphzS , ΔphzM , and ΔphzH), or involved in biofilm formation (i.e., ΔretS , ΔfliC , and ΔpilB). Luria-Bertani (LB), minimal medium (AB) and synthetic waste water (WW) were used as the growth media. All experiments were conducted in a 150 ml electrochemical half cell with a 3-electrode-setup. The quorum sensing regulatory mutant ΔretS , exhibited significantly higher current production than the wildtype and all other mutants in all growth media (18.03 $\mu\text{A}/\text{cm}^2$ vs. 2.04 $\mu\text{A}/\text{cm}^2$ for wildtype in LB, 8.02 $\mu\text{A}/\text{cm}^2$ vs. 0.71 $\mu\text{A}/\text{cm}^2$ for wildtype in AB, 0.51 $\mu\text{A}/\text{cm}^2$ vs. 0.27 $\mu\text{A}/\text{cm}^2$ for wildtype in WW). Cyclic voltamograms indicated the presence of redox active substances other than pyocyanin for ΔretS . In addition, the mutants ΔphzH , ΔretS , and the wildtype strain produced mediators with similar mid-peak potentials. Compared to ΔretS , this indicates the possible existence of alternative electron transfer mediators. Based on these results ΔretS was selected for ongoing experiments, which will also be included in the poster.

Biological and Environmental Engineering

The Manure Management Program: Monitoring on-farm anaerobic digester performance in NYS following the ASERTTI protocol

Jennifer L. Pronto*, Curt A. Gooch

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: jlp67@cornell.edu

A general approach to generating multifunctional nanoarchitectures from DNA-based ABC monomers

Jong Bum Lee*, Young Hoon Roh, Dan Luo

Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: jl539@cornell.edu

From a branched DNA labeled with quantum dots, gold nanoparticles, and polyethylene glycol monoacrylate, anisotropic, branched, and crosslinkable monomers (ABC monomers) were created. These multifunctional nano-architectures were used for detecting pathogen DNA as DNA nanobarcodes and encoded spherical polymers. Importantly, the spherical polymers were generated only in the presence of a specific DNA molecule, enabling highly-sensitive pathogen detection. Using this monomer system, we also designed a biocompatible multi-drug delivery vector that delivered both drugs and tracers simultaneously.

Self-assembly of DNA-lipid hybrid amphiphiles

Young Hoon Roh^{1*}, Dan Luo¹

¹: Dept. of Biological and Environmental Engineering,
Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: yr36@cornell.edu, address: Riley-Robb Hall, Ithaca, NY 14850

Liposomes, an important class of drug delivery vectors, are usually made of layers of phospholipids. Here, we report the synthesis of novel, DNA-based amphiphiles consisting of DNA building blocks and lipids and their self-assembly into various types of nanostructures. The morphologies and properties of these nanostructures can be easily controlled by selecting the DNA building blocks and the number of lipid chains tethered onto the branches of the DNA building blocks: a donut-shaped vesicular structure of DNA-lipid amphiphiles. Interestingly, the sizes of the vesicles were manipulated with various size ranges approximately from 5 μ m to 500 nm. It is expected that DNA-lipid amphiphiles and DNA-liposomes will become new tools for designing and synthesizing novel, drug delivery materials and for tracking self-assembling processes.

Unconventional DNA-mediated route to plasmonic nanoparticle superlattices

Wenlong Cheng^{1*}, Dan Luo¹

¹: Dept. of Biological and Environmental Engineering, Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: wc272@cornell.edu, address: Riley-Robb Hall, Ithaca, NY 14850

Gold nanoparticles assembled into spherical networks by peptides

Liang Ding^{1*}, Dan Luo¹

¹: Dept. of Biological and Environmental Engineering, Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: ld94@cornell.edu, address: Riley-Robb Hall, Ithaca, NY 14850

A cell-free protein producing gel

Nokyoung Park^{1*}, Hisakage Funabashi¹, Dan Luo¹

¹: Dept. of Biological and Environmental Engineering, Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: np84@cornell.edu, address: Riley-Robb Hall, Ithaca, NY 14850

DNA hydrogel microdroplets formation and its applications as scaffolds for biomaterials

Nokyoung Park^{1*}, Dan Luo¹

¹: Dept. of Biological and Environmental Engineering, Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: np84@cornell.edu, address: Riley-Robb Hall, Ithaca, NY 14850

Multiplexed pathogen detection via a portable fixcytometer

Nokyoung Park^{1*}, Mark Hartman¹, Dan Luo¹

¹: Dept. of Biological and Environmental Engineering, Cornell University, Riley-Robb Hall, Ithaca, NY 14850

*: Presenter, e-mail: np84@cornell.edu, address: Riley-Robb Hall, Ithaca, NY 14850