
2011 APPENDIX

Center for Biofilm Engineering

Montana State University
Bozeman

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RESEARCH:

CBE RESEARCH AREAS

Research at the Center for Biofilm Engineering is driven by industrial, environmental, and health issues of national importance. CBE research has contributed new insights into microbial processes in a wide variety of contexts.

CBE RESEARCH:

- is motivated by industrial concerns and involvement of industry partners;
- is conducted at multiple scales of observation, from molecular to field-scale;
- involves interdisciplinary investigations;
- provides relevant research opportunities for undergraduate and graduate students;
- is enhanced by productive collaborations with researchers at other institutions;
- is funded primarily by competitive grants, industrial memberships and sponsored projects; and
- produces both fundamental and applied results.

The CBE's long history of research success results from **adaptability** to new information and analytical technologies as well as **flexibility** in addressing biofilm issues in comprehensive ways, using its deep bench of **MSU researchers with diverse specialties** in biofilm studies.

APPLIED RESEARCH AREAS & PROJECTS

Biofilm control strategies antimicrobial efficacy | biocides | bioelectric effect | disinfectants | inhibitory coatings | nitrous oxide

Energy solutions biofuels | microbial fuel cells | coal-bed methane optimization

Environmental subsurface technologies bioremediation | wetlands | CO₂ sequestration | biobarriers

Health/medical biofilms chronic wound healing | catheter infections | oral health | food safety

Industrial systems & processes biofouling | biocorrosion | product contamination | microbe-metal interactions | biomineralization

Standardized methods product claims | regulatory issues | ASTM methods acceptance

Water systems drinking water quality | premise plumbing | water treatment | distribution systems

FUNDAMENTAL TOPICS

Biofilms in nature microbes in cold environments | role of biofilms in natural processes | thermophiles

Cellular/intracellular phenotype | genetics | metabolic pathways | proteomics

Ecology/physiology population characterization | spatial and temporal population dynamics

Multicellular/extracellular flow and transport in biofilm systems | material properties | quorum sensing | structure-function | heterogeneities | matrix

ANALYTICAL TOOLS & TECHNIQUES

Instrumentation microscopy | nuclear magnetic resonance imaging | gas chromatography | ToF-SIMS | micro-dissection

Methods development experimental design | variability | ruggedness | repeatability | statistical evaluation

Modeling cellular automata modeling | mathematics | hydrodynamics

Basic microbiology techniques total and direct counts | MIC determination | viable cell counts

Molecular biology techniques DNA extraction | PCR | DGGE | microarrays | sequencing

RESEARCH:

2010–2011 CBE RESEARCH PROJECTS

Research Area	Title	Principal Investigator	Funding Agency
Biofilms in Nature	NASA Fellowship: Heidi Smith	Foreman	NASA
Biofilms in Nature	Collaborative research: The biogeochemical evolution of dissolved organic matter in a fluvial system on the Cotton Glacier, Antarctica	Foreman	NSF
Biofilms in Nature	Collaborative research: Integrated high resolution chemical and biological measurements on the deep WAIS Divide Core. * ³	Foreman	NSF
Education	Biofilms: The Hypertextbook	Cunningham, Ross	NSF
Energy Solutions	Montana biodiesel initiative	Peyton	DOE
Energy Solutions	Environmental responses to geologic CO ₂ sequestrations	Cunningham	DOE EPSCoR
Energy Solutions	Basic science of retention issues, risk assessment and measurement, monitoring and verification for geologic CO ₂ sequestrations	Cunningham	DOE
Energy Solutions	Extremophilic microalgae: Advanced lipid and biomass production for biofuels and bioproducts	Peyton, Fields	DOE
Energy Solutions	EFRI-HyBi: Fungal processes for bioconversion	Peyton	NSF-ARRA
Environmental Technologies	Subsurface biofilm barriers for enhanced geologic sequestration of supercritical CO ₂	Cunningham, Spangler	DOE-ZERT
Environmental Technologies	Mobility of source zone heavy metals and radionuclides: The mixed roles of fermentative activity on fate and transport of U and Cr	Gerlach, Peyton	DOE
Environmental Technologies	ZERT II - Cunningham Task II	Cunningham	DOE-ZERT
Environmental Technologies	Plant, season, and microbial controls on complete denitrification in treatment wetlands	Stein	NSF
Environmental Technologies	Biocomplexity: Biogeochemical cycling of heavy metals in contaminated sediments at Lake Coeur d'Alene * ²	Peyton	NSF
Environmental Technologies	Microbial activity and precipitation at solution-solution mixing zones in porous media	Gerlach	DOE-ERSP
Environmental Technologies	Control of microbial processes for enhanced water treatment using floating island treatment systems	Camper, Cunningham	MBRCT
Infrastructure	MRI: Acquisition of a state of the art confocal microscope at the CBE	Stewart	NSF
Infrastructure	State of the art biological imaging facility	Stewart	MJ Murdock Charitable Trust
Medical Biofilms	Healing chronic wounds by controlling microbial biofilm	Stewart, James	NIH
Medical Biofilms	Novel chemical analysis of the biofilm-biomaterial interface	Carlson	NIH via University of Illinois
Methods Development	Antimicrobial test methodology	Goeres	EPA
Methods Development	Research support for standardizing a comprehensive biofilm efficacy test system	Goeres Cunningham	MBRCT

Research Area	Title	Principal Investigator	Funding Agency
Modeling	CMG Research	Klapper	NSF
Multicellular/ extracellular	Cohesive strength and detachment of bacterial biofilms	Stewart	NSF via University of Minnesota
Physiology & Ecology	Role of non-coding RNAs in <i>P. aeruginosa</i> biofilm development * ¹	Franklin	NIH
Physiology & Ecology	Virtual Institute for Microbial Stress & Survival	Fields	Lawrence Berkeley National Lab
Physiology & Ecology	Role of IbpA in maintaining viability of <i>P. aeruginosa</i> biofilm persister cells ¹	Franklin	NIH
Physiology & Ecology	Metabolic engineering of <i>Alicyclobacillus acidocaldarius</i> for lactic acid production from biomass derived monosaccharides	Carlson	Idaho National Lab
Water Systems	EPA Fellowship: Crystal Richards	Camper	EPA

* Denotes a project running through a different MSU department, but involving collaboration with CBE researchers and/or use of CBE facilities.

¹MSU Department of Microbiology

²MSU Department of Chemical and Biological Engineering

³MSU Department of Land Resources & Environmental Sciences

List of Acronyms

DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
MBRCT	Montana Board of Research and Commercialization Technology
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NSF	National Science Foundation
USDA	U.S. Department of Agriculture
ZERT	Zero Emissions Research and Technology

FY11 New CBE Research Grants (July 1, 2010 to June 30, 2011)

Sponsor	Title	PI	Period	Amount
NSF	Plant, Season, and Microbial Controls on Complete Denitrification in Treatment Wetlands	Stein	3 yrs	\$302,853
NASA	Heidi Smith's NASA Fellowship	Foreman	1 yr	\$30,000
NSF	MRI: Acquisition of a State of the Art Confocal Microscope at the CBE	Stewart	1 yr	\$498,433
M.J. Murdock Charitable Trust	State of the Art Biological Imaging Facility	Stewart	2 yrs	\$406,500
US Dept. of Energy	Montana BioDiesel Initiative	Peyton	1 yr	\$500,000
DOE-ZERT	ZERT II - Cunningham Task II	Cunningham	2 yrs	\$292,991
	Total grant awards to CBE for FY 2011			\$2,030,777

Research news

Million-dollar microscopes

Phil Stewart, Principal Investigator and CBE Director, received funding from the NSF-MRI Program and the M.J. Murdock Charitable Trust for the purchase of new confocal microscope equipment in the fall of 2010. The National Science Foundation awarded \$498,433 for the project: "MRI: Acquisition of a State of the Art Confocal Microscope at the Center for Biofilm Engineering." The NSF grant was awarded in conjunction with a complementary cost-sharing grant of \$406,500 from the M.J. Murdock Charitable Trust. Microscopy Facilities Manager **Betsey Pitts** worked with Leica to maximize the purchase: with a trade-in of old equipment, the total microscope purchase came to \$1.2 million.

The first microscope, an inverted Leica SP5, arrived at the CBE during the last week of February 2011 and was put into use immediately. Pitts and a group of five research staff and graduate students were trained by Leica engineers. The second confocal system, an upright, arrived in mid-April. Both new instruments are outfitted with heated stages, four excitation lasers, motorized stages, and either ultra-fast scanning or FLIM capability.

Features of new equipment

The new equipment will allow researchers to build on expertise the CBE has already developed in the field of biofilm imaging by funding critical upgrades to existing, but outdated confocal microscope instrumentation. The new systems have been customized to meet particular research needs and are equipped with multiple features such as fluorescence lifetime imaging (FLIM) capability for probing biofilm molecular microenvironments; an ultraviolet (UV) laser for imaging blue fluorescence; a heated stage and inverted microscope to allow medically relevant biofilm imaging; unlimited RAM, which will effectively remove a technological barrier to most experiments; and new fast scanning and sensitive detection technology—all of which will enable truly innovative science in the biofilm field.

Research applications of new equipment

This new microscope will facilitate interdisciplinary science and engineering on diverse topics ranging from algal biofuels to biofilms on medical devices. Examples of specific research projects that depend critically on sophisticated microscopy include:

- the interaction of human keratinocytes with staphylococcal biofilms,
- microbe-mineral interactions in environmental and medical systems,
- spatio-temporal patterns of gene expression,
- the action of biocides and antibiotics against biofilms,
- cellular age distributions in yeast biofilms,
- characterization of anaerobic biofilms with new fluorescence in-situ hybridization techniques,
- health implications of biofilms in drinking water systems,
- targeting antimicrobials to biofilms using engineered viral protein cages,
- visualization of biofilms in polar ice core samples, and
- development of advanced lipid and biomass production for biofuels from extremophilic microalgae.

At least 15 faculty from six academic departments will be served by the new instrument.

Impact on MSU students, staff and faculty

The CBE is a student-centered research entity and the CBE microscope facility has become what is considered a Core Research Facility on the MSU campus—regarded and supported as such by the MSU VP for Research Office. Staffed by a full-time microscope facilities manager (Betsey Pitts), the CBE microscope facility has been a centerpiece of the student research experience and training infrastructure at CBE.

There are several advantages of the CBE approach: 1) students and other users expand their technical education and experience, developing a deeper understand of microscope physics and technology, 2) collaboration and sharing of experience among users is promoted, 3) better results are obtained as users do not have the stress of a ticking meter racking up charges as times passes, and 4) all of the students, staff and faculty microscope users as well as the facilities manager, contribute to and benefit from what is now a vast amount of institutional knowledge on the subject of microscopy of biofilms.

RESEARCH:

CBE Associated Faculty and Their Specialties, 2010–2011

NAME	DEPARTMENT	SPECIALTY
Mark Burr	Land Resources & Environ Sciences	Microbial community analysis
Anne Camper	Civil Engineering	Biofilms in environmental systems
Ross Carlson	Chemical & Biological Engineering	Metabolic engineering, metabolic networks
Sarah Codd	Mechanical & Industrial Engineering	Magnetic resonance imaging
Kevin Cook	Mechanical & Industrial Engineering	Tool and machine design
Al Cunningham	Civil Engineering	Subsurface biotechnology and bioremediation
Jack Dockery	Mathematical Sciences	Mathematical models of biofilms
Matthew Fields	Microbiology	Physiology and ecology
Christine Foreman	Land Resources & Environ Sciences	Microbial ecology in cold temperature environments
Michael Franklin	Microbiology	Molecular genetics, gene expression, alginate
Gill Geesey	Microbiology	Molecular and cellular interactions at interfaces
Robin Gerlach	Chemical & Biological Engineering	Environmental biotechnology and bioremediation
Darla Goeres	Chemical & Biological Engineering	Standardized biofilm methods
Marty Hamilton	Mathematical Sciences: Statistics	Applied biostatistical thinking
Jeff Heys	Chemical & Biological Engineering	Fluid-structure interactions
Garth James	Chemical & Biological Engineering	Medical biofilms
Warren Jones	Civil Engineering	Water distribution systems
Isaac Klapper	Mathematical Sciences	Mathematical modeling
Zbigniew Lewandowski	Civil Engineering	Microsensors, chemical gradients, biofilm structure
Richard Macur	Chemical & Biological Engineering	Biofuels, geochemistry, geomicrobiology
Aurélien Mazurie	Microbiology	Bioinformatics
Bruce McLeod	Electrical & Computer Engineering	Bioelectric effect
David Miller	Mechanical & Industrial Engineering	Experimental mechanics
Andy Mitchell	Civil Engineering	Geomicrobiology
Al Parker	Mathematical Sciences: Statistics	Statistical models in biofilm systems
Brent Peyton	Chemical & Biological Engineering	Environmental biotechnology and bioremediation
Barry Pyle	Microbiology	Environmental, water, and food microbiology
Abbie Richards	Chemical & Biological Engineering	Environmental biotechnology
Rocky Ross	Computer Science	Web-based, active learning education
Joseph Seymour	Chemical & Biological Engineering	Magnetic resonance imaging
Otto Stein	Civil Engineering	Engineered waste remediation
Phil Stewart	Chemical & Biological Engineering	Biofilm control strategies
Paul Sturman	Civil Engineering	Biofilms in waste remediation and industrial systems
Peter Suci	Microbiology	Fungal biofilms
Tianyu Zhang	Mathematical Sciences	Mathematical modeling

CBE Associated Faculty Awards & News

Three CBE associated faculty members were among those announced by MSU as recipients of the university's 2011 faculty awards in January. The annual awards honor achievement in faculty research, teaching, outreach and creative projects. This year's the awards will be presented at the inaugural MSU Spring Convocation on January 11. In keeping with the CBE's goal to provide high quality interdisciplinary research and education, it is of particular value to the CBE that the three associated faculty member awardees represent different disciplines.

Provost's Excellence in Outreach Award

Otto Stein, professor in the Department of Civil Engineering, was selected as one of two 2011 recipients of MSU's Provost's Excellence in Outreach Award. He received a \$2,000 honorarium.

Stein is lead faculty adviser for the MSU student chapter of Engineers Without Borders. As such, he has led the group to national and international prominence, empowering the students to be global thinkers and actors, while simultaneously overseeing an infrastructural revolution in the Khwisero region of rural western Kenya. In the past four years, EWB has raised more than \$300,000 to support its work in Kenya and sent 10 teams of MSU students to Khwisero to work on water and sanitation projects. Directly benefiting an estimated 3,000 Kenyans, the students have drilled wells, installed hand water pumps, built composting and bio-gas latrines, implemented hand-washing programs, established a community advisory board and are currently designing a water distribution pipeline.

Otto Stein's research has focused on the use of wetlands systems to remove contaminants from polluted water sources, with particular interest in the influence of seasonal changes on performance. Bacterial biofilms associated with plant root systems provide much of the contaminant-reducing activity. Stein has supervised and mentored a number of CBE students.

Wiley Awards for Meritorious Research and Creativity

Matthew Fields, microbiology, and **Brent Peyton**, chemical and biological engineering, were two of four MSU faculty members who won this year's Charles and Nora L. Wiley Faculty Awards for Meritorious Research and Creativity. Each received \$2,000. Sponsored by the MSU Foundation, the prizes are given in honor of the Wileys, who were pioneer ranchers in eastern Montana.

Fields has made comprehensive contributions to the understanding of bioremediation of metals, radionuclides and organic contaminants found in U.S. Department of Energy facilities throughout the country. His work has also defined links between communities of microbes—the tiny organisms that have inhabited virtually every square inch of the earth's surface for the past 3.5 billion years. He has published 46 peer-reviewed papers and has been invited to present at multiple national meetings and at other universities. He is a tireless, enthusiastic, and inspiring mentor to CBE students.

Peyton is known as a tremendous catalyst for biofuel research at MSU. He is in the upper echelon of MSU researchers in terms of publication rate and competitive grants, with more than 80 peer-reviewed publications and multimillion dollar grant support. Peyton is also recognized for collaborative interdisciplinary research and as being a role model for junior and senior faculty, as well as MSU/CBE students. A PhD graduate of MSU and the CBE in 1992, Brent was one of the last CBE students mentored by Bill Characklis, the CBE's founding director.

Peyton and Kirk recognized for outstanding presentation

Brent Peyton, professor, chemical and biological engineering, and **Lisa Kirk**, PhD, land resources and environmental sciences, were recognized by the Environmental Division of the Society for Mining, Metallurgy, and Exploration (SME) for an outstanding presentation as part of the Environmental Program at the 2011 SME Annual Meeting and Exhibit in Denver, Colorado. Their presentation, "New insights on metal biogeochemistry and the microbial ecology of mine waste—is the mining industry putting them to good use?" was selected to receive the award by a committee that evaluated nearly 90 presentations based on technical content and presentation quality. As Outstanding Presentation winners, each author will receive a certificate of recognition. In addition, award winners will be announced in the June issue of Mining Engineering magazine. Finally, the Environmental Division has forwarded the names of the authors and title of presentation to SME as an excellent candidate for SME's Henry Krumb Lecture series.

2011 College of Engineering Awards

Two CBE faculty members were honored at the College of Engineering Celebration May 6, 2011. **Joseph Seymour**, professor, chemical and biological engineering, received a **COE Faculty Award for Excellence in Research**. **Kevin Cook**, assistant professor, mechanical engineering technology, received a **COE Faculty Award for Excellence in Outreach/Service**.

CBE 2011 Faculty Award

The CBE presented its **2011 Outstanding Faculty Award** to **Christine Foreman**, associate research professor, land resources and environmental sciences. It was awarded in recognition of Christine's deep commitment to interdisciplinary research and education, exceptional mentoring of graduate and undergraduate students and visitors, and unselfish contributions to CBE teamwork. Christine serves as a model of generosity, creativity, organization, and academic excellence.

CBE Staff Awards & News

MSU Employee Recognition

Betsey Pitts, CBE research associate and microscope facilities manager, was one of five recipients of the 2011 Montana State University Employee Recognition Award selected from a group of 59 nominees. MSU President Waded Cruzado presented the awards, which honor outstanding performance and contributions by classified and professional employees, at a ceremony and reception Wednesday, March 23. Betsey's nomination was supported not only by faculty, staff, and students at the CBE, but numerous MSU personnel across campus with whom she has worked in a variety of contexts. Thirty-nine colleagues from 14 MSU departments and offices wrote letters of recommendation, as well as numerous former students who have graduated from MSU and sent their support from afar.

New Staff

Adrienne (Adie) Phillips was hired to work on ongoing carbon sequestration and biomineralization projects in Al Cunningham and Robin Gerlach's lab. She has recently returned to Montana after working in New Jersey with an environmental consulting company. Adie has an MS in environmental engineering from Montana State University and she worked as a research engineer for Al Cunningham and Robin Gerlach's group from 2005–2008.

Eunsung Kan was hired as a postdoctoral research associate, starting March 1. Eunsung earned a PhD in chemical and environmental engineering from the University of California, Riverside. Following graduation, he worked as a research associate with the US EPA and as an assistant professor of chemical engineering and petroleum engineering in the United Arab Emirates. He is working with the Ross Carlson and Brent Peyton laboratories studying *in silico* and experimental aspects of biofuels production from novel cellulolytic fungi.

Kristen Griffin started work at the CBE January 31. Kristen replaced Diane Williams (retired in December 2010) in a newly re-defined position as Technology Development Specialist. Her position facilitates and optimizes technology transfer and information exchange between CBE personnel and Industrial Associates and other collaborators, through the CBE conferences and content management of the CBE's web site. Kristen came to the CBE from Mountain Destinations, an events and meetings company, where her position as the CBE's Account Manager brought her into contact with the CBE during the past two years.

Ellen Lauchnor joined the CBE as a postdoctoral researcher in April. Ellen received her PhD in environmental engineering in Lewis Semprini's lab at Oregon State University. She is working with Robin Gerlach and Al Cunningham on biomineralization related projects, studying biofilm-induced calcium carbonate precipitation in porous media. No stranger to the CBE, Ellen has previous CBE experience involving research on medical biofilms using confocal scanning laser microscopy and scanning electron microscopy while she pursued her BS in chemical engineering in 2005.

Retired

In late December 2010, the CBE said farewell to longtime staff member Diane Williams, media/information specialist. Diane began working as an administrative assistant for Bill Characklis, the CBE's founding director, in 1985—a full five years before the CBE's National Science Foundation Engineering Research Center award.

RESEARCH:
PUBLICATIONS
June 2010–May 2011

2010 Publications

Anesio AM, Sattler B, **Foreman C**, Telling J, Hodson A, Tranter M, Psenner R, "Carbon fluxes through bacterial communities on glacier surfaces," *Annals of Glaciology*, 2010, 51(56):32–40. 2010-037

Aston J, Peyton BM, Lee BD, Apel WA, "Effects of cell condition, pH, and temperature on lead, zinc, and copper sorption to *Acidithiobacillus caldus* strain BC13," *J Hazard Mater*, 2010, 184:34–41. 2010-047

Aston J, Peyton BM, Lee BD, Apel WA, "Effects of ferrous sulfate, inoculum history, and anionic form on lead, zinc, and copper toxicity to *Acidithiobacillus caldus* strain BC13," *Environ Toxicol Chem*, 2010, 29(12):2669–2675. 2010-048

Carlson RP, Taffs RL, "Molecular-level tradeoffs and metabolic adaptation to simultaneous stressors," *Curr Opin Biotechnol*, 2010, Jul 14. 2010-027

Cotter JJ, O'Gara JP, **Stewart PS, Pitts B**, Casey E, "Characterization of a modified rotating disk reactor for the cultivation of *Staphylococcus epidermidis* biofilm," *J Appl Microbiol*, 2010, 109(6):2105–2117. 2010-035

Cummins C, Doyle JT, Kindness L, Lefthand MJ, Bear Don't Walk UJ, Bends A, **Broadaway SC, Camper AK**, Fitch R, Ford TE, Hamner S, Morrison AR, **Richards CL**, Young SL, **Eggers MJ**, "Community-based participatory research in Indian country: Improving health through water quality research and awareness," *Family & Community Health*, 2010, 33(3):166–174. 2010-020

Davison WM, Pitts B, Stewart PS, "Spatial and temporal patterns of biocide action against *Staphylococcus epidermidis* biofilms," *Antimicrob Agents Chemother*, 2010, 54(7):2920–2927. 2010-025

Dewan A, Van Wie B, Beyenal H, **Lewandowski Z**, "The microbial fuel cell as an educational tool," *Chem Eng Ed*, 2010, 44(2):157–165. 2010-019

Dieser M, Nocker A, Priscu JC, **Foreman CM**, "Viable microbes in ice: Application of molecular assays to McMurdo Dry Valley lake ice communities," *Antarct Sci*, 2010, 22(5):470–476. 2010-033

Ebigbo A, Helmig R, **Cunningham AB**, Class H, **Gerlach R**, "Modeling biofilm growth in the presence of carbon dioxide and water flow in the subsurface," *J Adv Water Resour*, 2010, 33:762–781. 2010-028

Folsom JP, Richards L, **Pitts B, Roe F**, Ehrlich GD, **Parker A**, Mazurie A, **Stewart PS**, "Physiology of *Pseudomonas aeruginosa* in biofilms as revealed by transcriptome analysis," *BMC Microbiol*, 2010, Nov 17; 10(1):294. 2010-036

Gerlach R, Cunningham AB, "Influence of biofilms on porous media hydrodynamics," In: *Porous Media: Applications in Biological Systems and Biotechnology*, ed. Vafai K; CRC Press Taylor Francis Group, 2010, pp 173–230. 2010-032

Khan MT, **Pyle BH, Camper AK**, "Specific and rapid enumeration of viable but non-culturable and viable-culturable Gram negative bacteria using flow cytometry," *Appl Environ Microbiol*, 2010, 76(15):5088–5096. 2010-021

Lipp C, Kirker K, Agostinho A, James G, Stewart P, "Testing wound dressings using an in vitro wound model," *J Wound Care*, 2010, 19(6):220–226. 2010-022

Mitchell AC, Dideriksen K, Spangler LH, **Cunningham AB, Gerlach R**, "Microbially enhanced carbon capture and storage by mineral-trapping and solubility-trapping," *Environ Sci Technol*, 2010, 44(13):5270–5276. 2010-023

Moberly JG, Staven A, Sani RK, **Peyton BM**, "Influence of pH and inorganic phosphate on toxicity of zinc to *Arthrobacter* sp. isolated from heavy-metal-contaminated sediments," *Environ Sci Technol*, 2010, 44(19):7302–7308. 2010-026

Rochelle PA, **Camper AK**, Nocker A, **Burr M**, "Are they alive? Detection of viable organisms and functional gene expression using molecular techniques," Ch. 8, In: *Environmental Microbiology: Current Technology and Water Applications*, Keya Sen and Nic Ashbolt, eds, Horizon Press, 2010. 2010-049

Sabalowsky AR, Semprini L, “Trichloroethene and cis-1,2-dichloroethene concentration-dependent toxicity model simulates anaerobic dechlorination at high concentrations: I. Batch-fed reactors,” *Biotechnol Bioeng*, 2010, 107(3):529–539. 2010-041

Sabalowsky AR, Semprini L, “Trichloroethene and cis-1,2-dichloroethene concentration-dependent toxicity model simulates anaerobic dechlorination at high concentrations: II: Continuous flow and attached growth reactors,” *Biotechnol Bioeng*, 2010, 107(3):540–549. 2010-042

Sattler B, Storrie-Lombardi MC, **Foreman CM**, Tilg M, Psenner R, “Laser-induced fluorescence emission (LIFE) from Lake Fryxell (Antarctica) cryoconites,” *Annals of Glaciology*, 2010, 51(56):145–152. 2010-038

Suci P, Kang S, Gmu R, Douglas T, Young M, “Targeted delivery of a photosensitizer to aggregatibacter actinomycetemcomitans biofilm,” *Antimicrob Agents, Chemother*, 2010, 54(6):2489–2496. 2010-043

Szomolay B, **Klapper I**, Dindos M, “Analysis of adaptive response to dosing protocols for biofilm control,” *SIAM J Appl Math*, 2010, 70(8):3175–3202. 2010-045

Tavakkol Z, **Samuelson D**, **deLancey Pulcini E**, Underwood RA, Usui ML, **Costerton JW**, **James GA**, Olerud JE, Fleckman P, “Resident bacterial flora in the skin of C57BL/6 mice housed under SPF conditions,” *J Am Assoc Lab Anim Sci*, 2010, 49(5):1–4. 2010-031

Villa F, Albanese D, Giussani B, **Stewart PS**, Daffonchio D, Cappitelli F, “Hindering biofilm formation with zosteric acid,” *Biofouling*, 2010, Aug; 26(6):739–52. 2010-044

Vo G, **Brindle E**, **Heys JJ**, “An experimentally validated immersed boundary model of fluid-biofilm interaction,” *Water Sci Technol*, 2010, 61(12):3033–3040. 2010-034

Wang Q, **Zhang TY**, “Review of mathematical models for biofilms,” *Solid State Communications*, Jun 2010, 150(21-22 Sp. Iss.):1009–1022. 2010-046

Wolcott RD, Rumbaugh KP, **James G**, Schultz G, Phillips P, Yang Q, Watters C, **Stewart PS**, Dowd SE, “Biofilm maturity studies indicate sharp debridement opens a time-dependent therapeutic window,” *J Wound Care*, 2010, 19(8):320–328. 2010-030

Zhang T, **Klapper I**, “Mathematical model of biofilm induced calcite precipitation,” *Water Sci Technol*, 2010, 61(11):2957–64. 2010-040

Zhao G, Hochwalt PC, Usui ML, Underwood RA, Singh PK, **James GA**, **Stewart PS**, Fleckman P, Olerud JE, “Delayed wound healing in diabetic (db/db) mice with *Pseudomonas aeruginosa* biofilm challenge: A model for the study of chronic wounds,” *Wound Rep Reg*, 2010, 18(5):467–477. 2010-039

Zuroff TR, **Bernstein H**, Lloyd-Randolfi J, Jimenez-Taracido L, **Stewart PS**, **Carlson RP**, “Robustness analysis of culturing perturbations on *Escherichia coli* colony biofilm beta-lactam and aminoglycoside antibiotic tolerance,” *BMC Microbiol*, 2010, 10:185. 2010-024

2011 Publications

Ammons MC, Ward LS, **James GA**, “Anti-biofilm efficacy of a lactoferrin/xylitol wound hydrogel used in combination with silver wound dressings,” *Intl Wound J*, 2011, 8(3):215-322. 2011-008

Ammons MC, Ward LS, Dowd S, **James GA**, “Combined treatment of *Pseudomonas aeruginosa* biofilm with lactoferrin and xylitol inhibits the ability of bacteria to respond to damage resulting from lactoferrin iron chelation,” *Int J Antimicrob Agents*, 2011, 37(4):316–23. 2011-012

Aston JE, Apel WA, Lee BD, **Peyton BM**, “Growth effects and assimilation of organic acids in chemostat and batch cultures of *Acidithiobacillus caldus*,” *World J Microbiol Biotechnol*, 2011, 27(1), 153–161. 2011-018

Fittipaldi M, Codony F, Agrados B, **Camper A**, Morato J, “Viable read-time PCR in environmental samples: Can all data be interpreted directly?” *Microb Ecol*, 2011 Jan, 61(1):7–12. 2011-022

Cunningham AB, **Gerlach R**, Spangler L, **Mitchell AC**, Parks S, **Phillips A**, “Reducing the risk of well bore leakage using engineered biomineralization barriers,” *Energy Procedia*, 2011, 4:5178–5185. 2011-019

Costerton JW, Post JC, Ehrlich GD, Hu FZ, Kreft R, Nistico L, Kathju S, Stoodley P, Hall-Stoodley L, Maale G, **James G**, Sotereanos N, DeMeo P, "New methods for the detection of orthopedic and other biofilm infections," *FEMS Immunol Med Microbiol*, 2011, 61(2):133–40. 2011-013

Foreman CM, Dieser M, Greenwood M, Cory RM, Laybourn-Parry J, Lisle JT, Jaros C, Miller PL, Chin YP, McKnight DM, "When a habitat freezes solid: Microorganisms over-winter within the ice column of a coastal Antarctic lake," *FEMS Microbiol Ecol*, 2011, 76(3): 401–412. 2011-010

Fridjonsson EO, **Seymour JD, Schultz LN, Gerlach R, Cunningham AB, Codd SL**, "NMR measurement of hydrodynamic dispersion in porous media subject to biofilm mediated precipitation reactions," *J Contam Hydrol*, 2011, 120-121:79–88. 2011-002

Gerlach R, Field EK, Viamajala S, **Peyton BM**, Apel WA, **Cunningham AB**, "Influence of carbon sources and electron shuttles on ferric iron reduction by *Cellulomonas* sp. strain ES6," *Biodegradation*, 2011, 2011 Sep; 22(5):983-95. 2011-014

Jones WL, Sutton MP, McKittrick L, **Stewart PS**, "Chemical and antimicrobial treatments change the viscoelastic properties of bacterial biofilms," *Biofouling*, 2011, 27(2):207–215. 2011-011

Khan MMT, **Stewart PS**, Moll DJ, Mickols WE, **Nelson SE, Camper AK**, "Characterization and effect of biofouling on polyamide reverse osmosis and nanofiltration membrane surfaces," *Biofouling*, 2011, 27(2):173–183. 2011-001

Khan MMT, Takizawa S, **Lewandowski Z, Jones WL, Camper AK**, Katayama H, Kurisu F, Ohgaki S, "Membrane fouling due to dynamic particle size changes in the aerated hybrid PAC–MF system," *J Membrane Sci*, 2011, 371:99–107. 2011-006

Kozubal MA, **Dlagic M, Macur RE**, Inskeep WP, "Terminal oxidase diversity and function in *Metallosphaera yellowstonensis*: Gene expression and protein modeling suggest mechanisms of Fe(II) oxidation in the sulfobacterales," *Appl Environ Microbiol*, 2011, 77(5):1844–1853. 2011-005

Lewandowski Z, Boltz JP, "Biofilms in water and wastewater treatment," In: Peter Wilderer (ed.) *Treatise on Water Science*, Oxford: Academic Press 2011, Vol 4: pp. 529–570. 2011-004

Lindley B, Wang Q, **Zhang TY**, "A multicomponent model for biofilm-drug interaction," *Discrete and Continuous Dynamical Systems–Series B*, Mar 2011, 15(2):417–456. 2011-017

Renslow R, **Lewandowski Z**, Beyenal H, "Biofilm image reconstruction for assessing structural parameters," *Biotechnol Bioeng*, 2011, 108(6):1383–1394. 2010-009

Richards CL, Buchholz BJ, Ford TE, **Broadaway SC, Pyle BH, Camper AK**, "Optimizing the growth of stressed *Helicobacter pylori*," *J Microbiol Methods*, 2011, 84:174–182. 2011-003

Sivaswamy V, Boyanov MI, **Peyton BM**, Viamajala S, **Gerlach R**, Apel WA, Sani RK, Dohnalkova A, Kemner KM, Borch T, "Multiple mechanisms of uranium immobilization by *Cellulomonas* sp. strain ES6," *Biotechnol Bioeng*, 2011, 108(2):264–276. 2011-020

Taylor CR, Hook PB, **Stein OR**, Zabinski CA, "Seasonal effects of 19 plant species on COD removal in subsurface treatment wetland microcosms," *Ecological Eng*, 2011, 37(5):703–710. 2011-016

VanEngelen MR, Szilagyi RK, **Gerlach R**, Lee BD, Apel WA, **Peyton BM**, "Uranium exerts acute toxicity by binding to pyrroloquinoline quinone cofactor," *Environ Sci Technol*, 2011, 45(3):937–942. 2011-021

Vo GD, Heys J, "Biofilm deformation in response to fluid flow in capillaries," *Biotechnol Bioeng*, 2011, 108(8):1893–1899. 2011-015

Williams DL, Woodbury KL, **Parker AE**, Bloebaum RD, "A modified CDC biofilm reactor to produce mature biofilms on the surface of PEEK membranes for an in vivo animal model application," *Curr Microbiol*, 2011, 62(6):1657–1663. 2011-007

RESEARCH:
PRESENTATIONS
June 2010–May 2011

Sarah Codd, associate professor of mechanical and industrial engineering, and **Joe Seymour**, professor of chemical and biological engineering, presented a two-day workshop: “Transport processes in biofouled porous media and hydrogels” at Bend Research Inc., Bend, OR, May 27–28, 2010.

Robin Gerlach, associate professor of chemical and biological engineering, as an invited speaker presented “Role of biofilms and biomineralization in deep geological carbon sequestration” at the PNNL CCS Workshop, Richland, WA, June 4, 2010.

Heidi Smith, PhD student in land resources and environmental sciences, presented “Microbial growth and diversity in a humic-free environment on the Cotton Glacier, Antarctica,” International Polar Year Conference, Oslo, Norway, June 6–13, 2010.

Mari Eggers, PhD student in microbiology, presented “Translating community based participatory research: Lessons learned” and “Community based risk assessment of exposure to contaminants—Crow Indian Reservation” at the Environmental Protection Agency Tribal Science Forum, Traverse City, MI, June 7–10, 2010. Co-authors: Ford T, Cummins C, Doyle J, Kindness L, and Young S

Phil Stewart, CBE Director, presented “Physiology of *Pseudomonas aeruginosa* in biofilms as revealed by transcriptome analysis,” Department of Microbiology, University of Washington, Seattle, Washington, December 7, 2010.

Phil Stewart presented “Biofilms in the Oilfield,” ExxonMobil Upstream Research, Houston, Texas, June 11, 2010.

Lisa Kirk, PhD student in land resources and environmental sciences, presented “Speciation of selenium by facultative bacteria in phosphate mine waste,” Goldschmidt Conference—Earth, Energy, and the Environment,” Knoxville, TN, June 13–18, 2010. Co-authors: Stewart B, **Macur R**, **Gerlach R**

Mari Eggers, PhD student in microbiology, and Sara Young presented “Community based risk assessment on the Crow Reservation,” National IDeA Symposium of Biomedical Research Excellence (NISBRE), Bethesda, MD, June 16–18, 2010. Eggers and the Dr. Camper/Crow research group received a travel award for their research, in recognition of scientific merit. Their poster

was highlighted in the Environmental Health poster session.

Matthew Fields, assistant professor of microbiology, presented “Transcriptomes and proteomes: Identification of physiological constraints related to biofilm growth and bioremediation in *Desulfovibrio vulgaris*,” and “Methane and syntrophic biofilms,” San Juan, Puerto Rico Society of Microbiology Annual Meeting, June 17–18, 2010.

Kevin Cook, assistant professor of mechanical engineering technology, presented “Implementing a formal collaborative mechanical engineering technology internship program with campus research activities” in Session #2550: *Industry collaborations in engineering technology*, at the 2010 ASEE Annual Conference and Exposition, Louisville, KY.

Paper citation: **Cook K, Adam S, Anderson S, Goeres D, Walker D, Cunningham A**, “Implementing a formal collaborative mechanical engineering technology internship program with campus research activities,” *Proceedings of the 2010 ASEE Annual Conference and Exposition*, Louisville, Kentucky, 2010.

Robin Gerlach, associate professor of chemical and biological engineering, as an invited speaker presented “Influence of microbial biofilms on reactive transport in porous media,” Third International Conference on Porous Media and its Applications in Science, Engineering and Industry, Montecatini, Italy, June 20–25, 2010.

Betsey Pitts, CBE microscope facilities manager, presented “Using fluorescence microscopy to assess microbial activity and antimicrobial performance in biofilms” at the Colgate-Palmolive Global Technology Center, Piscataway, NJ, June 22, 2010.

Al Cunningham, professor of civil engineering, presented a four-day lecture on biodegradation at *Upscaling and modeling of reactive transport in partially saturated porous media*, a summer school course at the Universiteit Utrecht, The Netherlands, July 2–9, 2010.

Anne Camper, professor of civil engineering, presented an overview of water sample results, McCormick & Baxter Annual Technical Team Meeting, Oregon DEQ & GSI Water Solutions, Portland, OR, July 7–9, 2010. This was a technical meeting reviewing information associated with the McCormick & Baxter creosote contamination site in Portland, OR.

Isaac Klapper, professor of mathematical sciences, was a co-organizer and presenter at the 2010 SIAM Conference on Life Sciences Pittsburgh, PA, July 10–15, 2010. He presented “An exclusion principle for biofilm models” in

the *Mini-symposium on Bacterial Biofilms: Models, Analysis, and Simulation*, and “Electrodiffusion in microbial biofilms” in the *Mini-symposium on Fluids with Dynamic Microstructure*.

Luis O. Serrano Figueroa, PhD student in microbiology, and **Abigail Richards**, assistant professor of chemical and biological engineering, presented a poster “Siderophore production by haloalkaliphilic bacteria under varied physiologic conditions,” BioMetals 2010, Tucson, AZ, July 25–30, 2010.

Crescentia Cummins, Myra Lefthand, Ada Bends, and **Mari Eggers**, PhD student in microbiology, presented “Community based risk assessment of exposure to contaminants via water sources on the Crow Reservation in Montana,” Indigenous Women in Science Network Annual Conference, Missoula, MT, August 5–7, 2010.

Zbigniew Lewandowski, professor of civil engineering, presented “Effect of location on the performance of benthic microbial fuel cells” and chaired the “Microbial Fuel Cells” session, August 15–18, 2010. Co-authors: Dewan A, Euwing T, Nielsen ME, Reimers C, Chadwick B, Richter K, Beyenal H

Megan Elam, OSU, visiting researcher in the summer of 2010, presented a poster “Microbially enhanced calcite precipitation in porous media,” ISME: Stewards of a Changing Planet, Seattle, WA, August 22–27, 2010. Co-authors: **Gerlach R, Franklin M, Bugni S**, Colwell F

Erin Field, PhD student in microbiology, presented the poster “Microbial ecology and metal transformations at a simulated low-level waste site,” ISME: Stewards of a Changing Planet, Seattle, WA, August 22–27, 2010. Co-authors: **D’Imperio S, Van Engelen M, Peyton B, Gerlach R**, Lee B, Miller A, Apel W

Natasha Mallette, PhD student in chemical and biological engineering, presented “*Gliocladium roseum*: Exploration and optimization of fuel production” at the American Chemical Society Fall 2010 National Meeting, Boston, MA, August 23, 2010.

Brad Ramsay, CBE research assistant, presented the poster “Isolation and characterization of a sulfate-reducing bacterium from uranium(VI)-contaminated groundwater,” 13th International Symposium on Microbial Ecology, Seattle, WA, August 23, 2010. Co-authors: Carroll S (Oak Ridge National Lab), Hazen T (UC-Berkeley), **Fields M** (MSU-CBE)

Elliott Barnhart, masters student in microbiology, presented a poster “Analysis of methane producing communities within underground coal beds” at the 13th International Symposium on Microbial Ecology (ISME):

Stewards of a Changing Planet, Seattle, WA, August 27, 2010. Co-authors: **Fields M, Cunningham A, Gerlach R**, Wheaton J, Meredith E

Kristen Brileya, PhD student in microbiology, gave a platform presentation, “Colocalization of ‘syntrophs’ in a methanogenic biofilm,” at the 13th International Symposium on Microbial Ecology, Seattle, WA, August 27, 2010. Co-authors: Hatzenpichler R, Hazen TC, Arkin AP, **Fields MW**

Erin Field, PhD student in microbiology, presented the poster “Microbial ecology and metal transformations at a simulated low-level waste site,” at the ISME: Stewards of a Changing Planet, Seattle, WA, August 22–27, 2010. Co-authors: **D’Imperio S, VanEngelen M, Peyton BM, Gerlach R**, Lee B, Miller AR, Apel, WA.

CBE Director **Phil Stewart** presented “Biofilms in the energy business,” Shell Technology Centre, Chester, UK, August 31, 2010.

Phil Stewart presented “Analysis of multiple hypotheses for antibiotic tolerance of *Staphylococcus epidermidis* in biofilms,” Biofilms 4, Winchester, UK, September 3, 2010.

Sabrina Behnke, PhD student in microbiology, presented “Comparing the disinfection of planktonic cells, biofilms, and detached biofilm particles in single species and dual species cultures,” Biofilms 4, Winchester, UK, September 1–3, 2010.

Robin Gerlach, Andy Mitchell, Logan Schultz, and **Al Cunningham** gave a platform presentation, “Biofilm-induced calcium carbonate precipitation in porous media systems,” at Biofilms 4, Winchester, UK, September 1–3, 2010.

Garth James, associate research professor in chemical and biological engineering, presented “Differential response of human keratinocytes to diffusible products from planktonic and biofilm cultures of *Staphylococcus aureus*,” Biofilms 4 International Conference, Winchester, UK, Sept 1–3, 2010.

Elliott Barnhart, masters student in microbiology, presented a poster “Analysis of methane producing communities within underground coal beds” for the inauguration events in honor of MSU President Waded Cruzado, MSU, Bozeman, MT September 9, 2010. Co-authors: **Cunningham A, Fields M**, Wheaton J, Meredith E

Al Parker, research engineer, as invited speaker presented “Drawing samples from high dimensional Gaussians using polynomials,” American Statistical

Association Montana Chapter meeting, Bozeman, MT, September 14, 2010.

Zbigniew Lewandowski, professor in civil engineering, presented “Mechanisms of biofilm formation and biofilm processes” and chaired the session “Biofilms in engineered systems—Ecological fundamentals and perspectives on the design and operation of reactor and membrane processes” at the Biofilms in Engineered Systems Workshop: IWA World Water Congress, Montreal, Canada, September 19–24, 2010.

Garth James, associate research professor in chemical and biological engineering, presented “Biofilms and infections associated with medical devices,” Becton Dickinson-Medical, Sandy, UT, September 21, 2010.

Crystal Richards, PhD student in microbiology and recipient of a 2009 Kopriva Graduate Student Fellowship, presented “*Helicobacter pylori* outside the human host,” Kopriva Science Seminar Series: AY 2010–2011, Montana State University, September 24, 2010.

Matthew Fields, assistant professor of microbiology, presented “Molecular phylogeny and phenotypic variation: Using genotype to phenotype relationships to identify lipid-producing microalgae,” Algal Biomass Summit, Phoenix, AZ, September 28–30, 2010.

Rich Macur, research assistant professor of chemical and biological engineering, presented “Development of standardized methods for the assessment of algal biofuel potential,” Standards Session, Algal Biomass Summit, Phoenix, AZ, September 28–30, 2010. Co-authors: **Gerlach R**, Cooksey K, **Gardner R**, Viamajala S, **Peyton B**

Brent Peyton, professor of chemical and biological engineering, presented “There is a lipid trigger: Evidence from Chlorophytes,” 2010 Algae Biomass Summit, Phoenix, AZ, September 28–30, 2010. Co-authors: **Gardner R**, Cooksey K, **Moll K**, Peters P

Phil Stewart, CBE director, as invited speaker presented “Biofilm disinfection” at the WEFTEC Workshop, New Orleans, LA, October 3, 2010.

Anne Camper, professor of civil engineering, presented “Biofilms in recycled/reclaimed water: Why should we care?” and “Factors impacting growth of biofilms,” WEFTEC, New Orleans, LA, October 2–4, 2010. She also chaired the session “Biofilms: The emerging issue for reuse waters.”

Otto Stein, professor of civil engineering, presented “Spatial and temporal variation of microbial functional groups within a sub-surface treatment wetland,” *Proceedings of the 12th International Conference on*

Wetland Systems for Water Pollution Control, October 4–9, 2010, Venice, Italy, pp 342–344. Co-authors: **Faulwetter JL**, **Burr MD**, **Camper AK**. Dr. **Stein** also presented the poster “Floating island treatment wetlands for domestic wastewater treatment” at the same conference (Proceedings, pp 1271–1278). Co-authors: **Faulwetter JL**, **Burr MD**, **Cunningham AB**, Stewart F, Camper AK

Phil Stewart, CBE director, as keynote speaker presented “Biofilms and the science behind their control with antimicrobial agents” at the “Biofilms: Here, There, and Everywhere” workshop, Israeli Society of Microbiology, sponsored by the Kibbutz Ginosar, Israel, November 4, 2010. Phil also presented, as an invited speaker, “Biofilms concepts applied to dental plaque,” Hebrew University, Jerusalem, November 7, 2010.

Hans Bernstein, masters student in chemical & biological engineering, presented “Using synthetic biology to engineer syntrophic microbial communities for bioprocess applications” at the 2010 AIChE Annual Meeting, Salt Lake City, UT, November 7–12, 2010. Co-author: Dr. Ross Carlson

Mike Franklin, professor of microbiology, presented “Laser microdissection of microbial biofilms” at the Recent Advances in Microbial Control Conference sponsored by the Society of Industrial Microbiology, Arlington, VA, November 7–10, 2010.

Garth James, associate research professor in chemical and biological engineering, presented “Advanced wound dressings vs. biofilms: In vitro performance” at the Recent Advances in Microbial Control Conference sponsored by Society of Industrial Microbiology, Arlington, VA, November 7–10, 2010.

Paul Sturman, CBE Industrial Coordinator, presented “Visualizing antimicrobial action in biofilms” at the Recent Advances in Microbial Control Conference sponsored by the Society of Industrial Microbiology Society of Industrial Microbiology, Arlington, VA, November 7–10, 2010.

Darla Goeres, assistant research professor of chemical and biological engineering, as an invited speaker presented “Validation of a biofilm disinfectant efficacy test” at the Recent Advances in Microbial Control Conference sponsored by the Society of Industrial Microbiology, Arlington, VA on November 7–10, 2010. Darla also presented “Single tube efficacy test: Results of a two-laboratory validation study” to the Microbiology Laboratory Branch of the Biological and Economic Analysis Division of the EPA, Ft Meade, MD, November 8, 2010.

Anne Camper, professor of civil engineering, as an invited speaker presented “Biofilm growth and control in drinking and industrial water systems,” Food Research Institute, UW-Madison, Focus on Food Safety Series, Water Safety and Quality Symposium, Madison, WI, November 10, 2010.

Andy Mitchell, assistant research professor, with co-authors **Al Cunningham**, professor of civil engineering, and **Robin Gerlach**, associate professor of chemical and biological engineering, gave an invited platform presentation, “Microbially enhanced carbon capture and storage—from pores to cores,” Fall Meeting American Geophysical Union, San Francisco, CA, December 13–17, 2010. Co-authors: **Mitchell AC**, Spangler LH

Al Cunningham and **Robin Gerlach** presented the poster “Utility of biofilms and biologically induced mineralization in geologic carbon sequestration,” Fall Meeting American Geophysical Union, San Francisco, CA, December 13–17, 2010. Co-authors: **Mitchell AC**, Spangler LH

Matthew Fields, assistant professor of microbiology, presented “*Desulfovibrio*: Physiology of the good, the bad, and the ugly” at Oak Ridge National Laboratory (ORNL), Oak Ridge, TN, December 15, 2010.

Elinor Pulcini, research manager of the CBE’s Medical Biofilm Laboratory, as invited speaker, presented “Microbiology and biofilms,” ExxonMobil Upstream Research Company, Houston, TX, January 14, 2011.

Phil Stewart, CBE director, presented “In vitro and in vivo models for investigation of chronic wound biofilms,” at Sanofi-Aventis, Bridgewater, NJ, January 21, 2011.

Matthew Fields, assistant professor of microbiology, presented “Microbial community dynamics of groundwater and sediments associated with heavy metal contamination” at the Symposium PNNL, Pasco, WA, February 6–8, 2011.

Elliott Barnhart, masters student in microbiology, presented the poster “Analysis of methane-producing communities within underground coal beds,” at the Montana Legislative Reception in conjunction with the Montana University System Board of Regents meeting, Helena, MT, March 3, 2011.

Phil Stewart, featured speaker, presented “Chronic Infections: The Biofilm Hypothesis,” at Bozeman’s “Café Scientifique,” sponsored by the INBRE program, Bozeman, MT, March 10, 2011.

Zbigniew Lewandowski, professor of civil engineering, presented “From microbial corrosion to microbial fuel

cells” at the University of Science and Technology, Hong Kong, China, March 14, 2011.

Garth James, associate research professor in chemical and biological engineering, presented “Biofilms and device-related infections” at the 2011 Bay Area Medical Device Conference, San Jose, CA, March 30, 2011.

Phil Stewart was interviewed on the topic “Chronic infections: The biofilm hypothesis” on Yellowstone Public Radio’s *Health Matters* show, Bozeman, MT, March 30, 2011.

Garth James presented the following posters at the Society for Healthcare Epidemiology of America (SHEA) Annual Scientific Meeting in Dallas, TX, April 1–3, 2011:

“Differences in bacterial transfer and fluid path colonization through needle free connector-catheter systems in vitro”

“The effect of chlorhexidine antimicrobial coating on the reduction of intraluminal catheter biofilm formation in a clinically simulated ovine model (Pilot Study)”

“Reduction of extraluminal bacterial colonization using chlorhexidine antimicrobial-coated PICC catheters in a clinically simulated ovine model (Pilot Study)”

Garth James presented a poster titled “Bacterial biofilms are oxygen sinks in murine and in vitro models of wound infection” at the Wound Healing Society Annual Meeting, Dallas, TX, April 14–17, 2011.

Christine Foreman, associate research professor of land resources and environmental sciences, was invited to present “Drill baby drill— but how to do it cleanly for microbial studies?” at the Drilling Science Community Planning Workshop, Washington, D.C., April 15–16, 2011.

Robin Gerlach, associate professor of chemical and biological engineering, was invited to present “Controlling carbonate mineral precipitation by biofilms for environmental and industrial benefit” at the Materials Research Society Meeting, San Francisco, CA, April 25–29, 2011.

Anne Camper, professor of civil engineering, presented “Interactions of organic matter, pipe materials, and disinfectants on biofilm growth in distribution systems,” International BTO-Conference, Amsterdam, The Netherlands, May 11–12, 2011.

EDUCATION:

Undergraduate Students: Summer 2010, Fall 2010, Spring 2011

1. Akkoyun, Kemal 'Kutay' (Stein)	M	Land Res & Environ Sci	Turkey
2. Bader, Erica (Richards)	F	Chem & Biol Eng	Boulder, CO
3. Blaskovich, John (Gerlach)	M	Chem & Biol Eng	Butte, MT
4. Bleem, Alissa (Carlson)	F	Chem & Biol Eng	Fort Collins, CO
5. Burns, Doug (Macur)	M	Cell Biol & Neurosci	Warrenville, IL
6. Butz, Thomas (Pulcini)	M	Chem & Biol Eng	Bozeman, MT
7. DeGroat, Alec (Fields)	M	Microbiology	Billings, MT
8. Doane, Danielle (Pulcini)	F	Nursing	Townsend, MT
9. Downey, Carey (Fields)	F	Chem & Biol Eng	Pocatello, ID
10. Durch, Amanda (James)	F	Chem & Biol Eng	Newell, SD
11. Fabich, Hilary (Codd/Seymour)	F	Chem & Biol Eng	Livingston, MT
12. Gittins, Tyler (Gerlach)	M	Chem & Biol Eng	Lawrence, KS
13. Gourneau, Terrance (Foreman)	M	Land Res & Environ Sci	Poplar, MT
14. Grimsrud, Whitney (Fields)	F	Immun & Infect Disease	Wolf Point, MT
15. Gulick, Stesha (Peyton)	F	Chem & Biol Eng	Helena, MT
16. Harrer, Travis (Gerlach)	M	Chem & Biol Eng	Great Falls, MT
17. Hinckley, Seth (James)	M	Cell Biol & Neurosci	Havre, MT
18. Hisey, Bennett (Camper)	M	Immun & Infect Disease	Bozeman, MT
19. Hoops, Jeanette "Bambi" (Pulcini)	F	Nursing (AIRO - Bridges)	Bozeman, MT
20. Johnson, Sarah (Stein)	F	Civil Eng (BREN)	Maple Grove, MN
21. Justin, Grant (Fields)	M	Microbiology	Bozeman, MT
22. Kennedy, Collette (Peyton)	F	Chem & Biol Eng	Fairbanks, AK
23. Kinsey, Danielle (Encarnacion)	F	Microbiology (AIRO-Bridges)	Harlem, MT
24. Littlewolf-Spencer, Gaehel (Richards)	M	Cell Biol & Neurosci	
25. McNelis, Kiera (R Carlson)	F	Chem & Biol Eng	Belgrade, MT
26. Mizel, Max (Livinghouse)	M	Chem & Biochem	Pueblo, CO
27. Morris, Dayla (Walker/Gerlach)	F	Chem & Biol Eng	Stockett, MT
28. Nejadamin, Mina (Seymour)	F	Chem & Biol Eng	Turkey
29. Oksness, Garret (Pulcini)	M	Microbiology	Bozeman, MT
30. Pankratz, Elle (Peyton)	F	Mech & Ind Eng	Clancy, MT
31. Paulson, Steven (Carlson)	M	Chem & Biol Eng	Cut Bank, MT
32. Popovitch, Paul (Richards)	M	Immun & Infect Disease	Kalispell, MT
33. Purdy, Kim (Richards)	F	Chem & Biol Eng	Buffalo, WY
34. Rothman, Adam (Gerlach)	M	Chem & Biol Eng	Anchorage, AK
35. Schmit, Amber (Foreman)	F	Chem & Biol Eng	Sheridan, WY
36. Schonenbach, Nicole (Peyton)	F	Chem & Biol Eng	Ashland, MT
37. Sen, Emel (Peyton)	F	Chem & Biol Eng	Turkey
38. Shaughnessy, Daniel (Walker)	M	Microbiology	New Brighton, MN
39. Sherick, Matthew (Seymour)	M	Chem & Biol Eng	Hudson, WI
40. Speakman, Keila (Fields)	F	Microbiology	Bozeman, MT
41. Stringham, Joshua (Gerlach)	M	Chem & Biol Eng	Bozeman, MT
42. Tate, Patrick (Carlson)	M	Chem & Biol Eng	Vancouver, WA
43. Thiel, Joseph (Stewart)	M	Chem & Biol Eng	Idaho Falls, ID
44. Toussaint, Jean-Paul (Carlson)	M	Chem & Biol Eng	Charlo, MT
45. Vadheim, Bryan (Heys)	M	Chem & Biol Eng	Miles City, MT
46. Garret Vo (Heys) [until Sep 2010]	M	Math Sci + Physics	San Francisco, CA
47. Young, Mary Lynn (Fields)	F	Chem & Biochem	Boise, ID
48. Zhang, Pei (Carlson)	M	Chem & Biol Eng	China

Undergraduates Summary: 2010-2011

Department	Male	Female	Total
Cell Biology & Neuroscience	3 M		3
Chemical & Biological Engineering	13 M	14 F	27
Chemistry & Biochemistry	1 M	1 F	2
Civil Engineering		1 F	1
Immunology & Infectious Disease	2 M	1 F	3
Land Resources & Environmental Sciences	2 M		2
Mathematical Sciences <u>and</u> Physics	1 M		1
Mechanical & Industrial Engineering		1 F	1
Microbiology	4 M	2 F	6
Nursing (1 Bridges)		2 F	2
Totals	26 M	22 F	48

EDUCATION:

Graduate Students: Summer 2010, Fall 2010, Spring 2011

*Graduating

Masters Candidates

1. Barnhart, Elliott (Fields/Cunningham)	M	Microbiology	Broadus, MT
2. Bugni, Steven (Gerlach)	M	Civil Eng	E. Helena, MT
3. Campbell, Margaret Elm (James)	F	Health Sciences	Woodinville, WA
4. Eustance, Everett (Peyton)	M	Chem & Bio Eng	Great Falls, MT
5. Franco, Lauren (Fields)	F	Microbiology	Moorpark, CA
6. Girardot, Crystal* (Peyton)	F	Chem & Bio Eng	Billings, MT
7. Moll, Karen (Peyton)	F	Chem & Bio Eng	Fairport, NY
8. O'Shea, Kelly* (Fields)	F	Microbiology	Colorado Springs, CO
9. Staven, Ari (Peyton)	F	Chem & Bio Eng	Georgetown, TX
10. Vo, Garret (Heys) [Starting Sep 2010]	M	Mech & Ind Eng	San Francisco, CA

PhD Candidates

1. Allen, Chris (Stein)	M	Civil: Environ Eng Opt	Eldorado Hills, CA
2. Behnke, Sabrina (Camper)	F	Microbiology	Voerde, Germany
3. Bell, Tisza (Peyton)	F	Microbiology	Littleton, CO
4. Bernstein, Hans (Carlson)	M	Chem & Bio Eng	Kalispell, MT
5. Brileya, Kristen (Fields)	F	Microbiology	Bozeman, MT
6. Connolly, James (Gerlach)	M	Civil: Environ Eng Opt	Post Falls, ID
7. De León, Kara (Fields)	F	Microbiology	Bozeman, MT
8. Eggers, Margaret (Camper)	F	Microbiology	California
9. Encarnacion, Gem (Camper)	F	Microbiology	The Philippines
10. Faulwetter, Jennifer* (Camper)	F	Microbiology	Morgan Hill, CA
11. Field, Erin* (Gerlach)	F	Microbiology	Deep River, CT
12. Gardner, Robert (Peyton)	M	Chem & Bio Eng	Afton, WY
13. Holsinger, Jordan (Fields)	M	Microbiology	Wolverine, MI
14. Hunt, Kristopher (Carlson)	M	Chem & Bio Eng	Thorp, WI
15. Jackson, Benjamin (Klapper)	M	Math Sci	Sheridan, OR
16. Kirk, Lisa* (Peyton)	F	Chem & Bio Eng	Bozeman, MT
17. Lohman, Egan (Gerlach)	M	Chem & Bio Eng	Pine, CO
18. Mallette, Natasha (Peyton)	F	Chem & Bio Eng	Fayetteville, AR
19. Plaggemeyer, Sara (Camper)	F	Microbiology	Big Timber, MT
20. Richards, Crystal* (Camper)	F	Microbiology	Bozeman, MT
21. Sandvik, Elizabeth (McLeod)	F	Chem & Bio Eng	Rapid City, SD
22. Secor, Pat* (Hughes)	M	Cell Bio & Neurosci	Bozeman, MT
23. Serrano Figueroa, Luis (A Richards)	M	Microbiology	Puerto Rico
24. Severson, Grant (James)	M	Microbiology	Claremore, OK
25. Smith, Heidi (Foreman)	F	LRES	Westford, VT
26. Sundararajan, Anitha* (Fields)	F	Microbiology	India
27. Taffs, Reed (Carlson)	M	Chem & Bio Eng	Helena, MT
28. Tigges, Michelle (Fields)	F	Chem & Biochem	Battle Lake, MN
29. Valenzuela, Jacob (Fields)	M	Chem & Biochem	San Luis Obispo, CA
30. VanKempen-Fryling, Rachel (Camper)	F	Chem & Biochem	Grand Rapids, MI
31. Vogt, Sarah (J Seymour)	F	Chem & Bio Eng	Rolla, MO

*Received degree

Graduate Students, 2010–2011

1: Cell Biology & Neuroscience

PhD: Secor, Pat: *Hughes*
 1 M

13: Chemical & Biological Engineering

MS: 4

1M Eustance, Everett: *Peyton*
 3 F Staven, Ari: *Peyton*
 Girardot, Crystal: *Peyton*
 Moll, Karen: *Peyton*

PhD: 9

5 M Bernstein, Hans: *Carlson*
 4 F Gardner, Robert: *Peyton*
 Hunt, Kristopher: *Carlson*
 Kirk, Lisa: *Peyton*
 Lohman, Egan: *Gerlach*
 Mallette, Natasha: *Peyton*
 Sandvik, Elizabeth: *McLeod*
 Taffs, Reed: *Carlson*
 Vogt, Sara: *Seymour*

3: Chemistry & Biochemistry

PhD: Tigges, Michelle: *Fields*
 1 M Valenzuela, Jacob: *Fields*
 2 F VanKempen-Fryling, Rachel: *Camper*

3: Civil / Environmental Engineering

MS: Bugni, Steven: *Gerlach*
 1M

PhD: Allen, Chris: *Stein*
 2 M Connolly, James: *Gerlach*

1: Health Sciences

MS: Campbell (Elm), Margaret: *James*
 1 F

1: Land Resources & Environmental Sciences

PhD: Smith, Heidi: *Foreman*
 1F

1: Mathematics

PhD: Jackson, Benjamin: *Klapper*
 1 M

1: Mechanical & Industrial Engineering

MS: Vo, Garret: *Heys* [starting Sept 2010]
 1 M

17: Microbiology

MS: 3 Barnhart, Elliott: *Fields/Cunningham*
 1 M Franco, Lauren: *Fields*
 2 F O'Shea, Kelly: *Fields*

PhD: 14

3 M Behnke, Sabrina: *Camper*
 11 F Bell, Tisza: *Peyton*
 Brileya, Kristen: *Fields*
 De León, Kara: *Fields*
 Eggers, Margaret: *Camper*
 Encarnacion, Gem: *Camper*
 Faulwetter, Jennifer: *Camper*
 Field, Erin: *Gerlach*
 Holsinger, Jordan: *Fields*
 Plaggemeyer, Sara: *Camper*
 Richards, Crystal: *Camper*
 Serrano Figueroa, Luis: *Richards*
 Severson, Grant: *James*
 Sundararajan, Anitha: *Fields*

Rotations and Traineeships

Molecular Bioscience

PhD Holsinger, Jordan: *Fields*
 1 M (see above, joined CBE program after rotation)

TOTALS

Total Grads: 41

Total MS: 10 4 M / 6 F
 Total PhD: 31 13 M / 18 F

Total Male: 17
 Total Female: 24

EDUCATION:

Graduating with advanced degrees: June 2010 – May 2011

Jennifer Faulwetter PhD, Microbiology, MSU, November 2010

Analysis of microbial biofilm community composition within constructed wetlands

Erin Field PhD, Microbiology, MSU, April 2011

Factors influencing the fate of chromium in soils: Microbial ecology, physiology and metal transformation studies

Crystal Girardot MS, Chemical and Biological Engineering, MSU, September 2010

UO₂ reoxidation in the presence of chelators and Fe(III) (hydr)oxides

Lisa Bithell Kirk PhD, Land Resources & Environmental Sciences, MSU, April 2011

In situ microbial reduction of selenium in backfilled phosphate mine overburden, S.E. Idaho

Kelly O'Shea MS, Microbiology, MSU, July 2010

Microbial conversion of biodiesel by-products to biofuel

Crystal Richards PhD, Microbiology, MSU, October 2010

The detection, characterization and cultivation of nonculturable *Helicobacter pylori*

Pat Secor PhD, Cell Biology and Neuroscience, MSU, December 2010

Impact of *Staphylococcus aureus* biofilm conditioned medium on inflammation and epithelialization in human keratinocytes

Anitha Sundararajan PhD, Microbiology, MSU, March 2011

Varied physiological responses of the facultative γ -proteobacterium, *Shewanella oneidensis* MR-1, and the δ -proteobacterium *Desulfovibrio vulgaris* Hildenborough to oxygen

EDUCATION:

2011 MSU Student Research Celebration: CBE Participants

MSU's undergraduate and graduate students shared their research at the annual Student Research Celebration Thursday, April 14, 2011. Among the 250 students presenting their research were numerous students, from a variety of departments, presenting results of their biofilm research connected with the Center for Biofilm Engineering (CBE). To read the abstracts, go to MSU's Research Celebration page, <http://www.montana.edu/usp/pages/conference.html>

Kemal Akkoyun, Chris Allen: Environmental Science and Environmental Engineering

"Determining the effect of carbon loading on denitrification rates in constructed wetlands"

Faculty mentors: Catherine Zabinski, Land Resources and Environmental Studies; **Otto Stein**, Civil Engineering, CBE

Kristen Brileya: Microbiology

"Colocalization of syntrophs in a methanogenic biofilm"

Faculty mentor: **Matthew Fields**, Microbiology, CBE

Steve Bugni, James Connolly: Environmental Engineering

"Controlling the distribution of microbially induced calcium carbonate precipitation in 2-D porous media reactors under pulse-flow conditions"

Faculty mentors: **Robin Gerlach**, Chemical and Biological Engineering, CBE; **Al Cunningham**, Civil Engineering, CBE

Lauren Franco: Microbiology

"Molecular and phenotypic characterization of three *Scenedesmus algal* isolates"

Faculty mentors: **Matthew Fields**, Microbiology, CBE; **Brent Peyton**, Chemical and Biological Engineering, CBE

Jordan Holsinger: Microbiology

"Rate comparisons for phototrophic and heterotrophic growth in algal strain CHLOR-1 isolates"

Faculty mentor: **Matthew Fields**, Microbiology, CBE

Elle Pankratz: Biological Engineering

"*Ascocoryne sarcooides*: Exploration of hydrocarbon production potential"

Faculty: **Brent Peyton**, Chemical and Biological Engineering, CBE

Steven Paulson: Chemical Engineering

"Construction and characterization of metabolically engineered *Escherichia coli* biofilm communities"

Faculty mentor: **Ross Carlson**, Chemical and Biological Engineering, CBE

James Connolly: Environmental Engineering

"Imaging biofilm and microbially induced calcium carbonate precipitation in 2D porous media reactors"

Faculty mentors: **Robin Gerlach**, Chemical and Biological Engineering, CBE; **Al Cunningham**, Civil Engineering, CBE

Hilary Fabich: Chemical Engineering

"Core shell particle technology and nuclear magnetic resonance micro-rheology"

Faculty mentors: **Sarah Codd**, Mechanical and Industrial Engineering, CBE; **Joe Seymour**, Chemical and Biological Engineering, CBE

Travis Harrer: Chemical and Biological Engineering

"Microbially induced calcium carbonate precipitation under radial flow conditions"

Faculty mentors: **Robin Gerlach**, Chemical and Biological Engineering, CBE; **Al Cunningham**, Civil Engineering, CBE

Nicole Schonenbach: Chemical Engineering

"Effects of temperature on two algal strains"

Faculty mentor: **Brent Peyton**, Chemical and Biological Engineering, CBE

Stesha Gulick: Chemical and Biological Engineering
 “Effects of differing light-dark cycles on the growth of microalgae to optimize biomass”
 Faculty mentor: **Brent Peyton**, Chemical and Biological Engineering, CBE

Matthew Sherick: Chemical Engineering
 “Isolation of bacterial alginate from *Pseudomonas aeruginosa* biofilms”
 Faculty mentors: **Sarah Codd**, Mechanical and Industrial Engineering, CBE; **Joe Seymour**, Chemical and Biological Engineering, CBE; **Michael Franklin**, Center for Biofilm Engineering

John Blaskovich: Chemical Engineering
 “Biological reduction of hexavalent chromium”
 Faculty mentor: **Robin Gerlach**, Chemical and Biological Engineering, CBE

Joshua Stringam: Chemical and Biological Engineering
 “Development of an injection strategy for homogenous calcium carbonate plugging by *Sprorsarcina pasteurii*”
 Faculty mentor: **Robin Gerlach**, Chemical and Biological Engineering, CBE

Student Awards

Nicole Schonenbach, undergraduate student in chemical and biological engineering and the CBE, was recently chosen as one of three MSU recipients of the prestigious National Science Foundation Graduate Research Fellowship. Nicole will receive \$30,000 plus tuition and fees to support three years of graduate education. She will be attending the University of California at Santa Barbara, where her research will focus on biomedicine and a drug delivery system for cancer. Graduating from MSU in May 2011, Nicole researched algal biodiesel in the lab of Brent Peyton, professor of chemical and biological engineering.

Three CBE undergraduate students were among forty-six students honored this spring during Montana State University’s 88th Day of Student Recognition. The award honors achievement in the areas of leadership, involvement in various campus-wide activities, and community service.

Kiera McNelis, a junior in chemical and biological engineering from Belgrade, MT, received the **Roskie Memorial Award**. The award goes to one undergraduate student who has shown outstanding leadership qualities. McNelis is a member of **Engineers Without Borders** and will travel to Kenya this summer as a project manager for EWB.

Hilary Fabich, a senior in chemical and biological engineering from Livingston, MT, received the **Ethelyn C. Harrison Award** presented to a senior woman who exemplifies high standards and concern for others. Fabich is a member of **Engineers Without Borders**, the **MSU Symphony Orchestra**, and has been an undergraduate researcher in the Magnetic Resonance Microscopy Lab for more than three years.

Joe Thiel, a junior in chemical and biological engineering from Idaho Falls, ID, received the **Christy Foundation Scholarship** awarded to a student who has brought special recognition to MSU based upon meritorious community leadership and service. He also received the **University Honors Program Leadership Award**. In addition, Thiel was inducted into **Septemviri**. This senior honorary recognizes seven outstanding juniors based upon extraordinary scholarship, leadership and service to MSU. Thiel is the president of Phi Kappa Phi, the vice president of **Engineers Without Borders**, and an **ASMSU Senator**.

On September 13, 2010, **Luis O. Serrano Figueroa** received the **Pfizer Leadership Award** as a 2010 graduate from the Master in Industrial Pharmacy program at the University of Puerto Rico. Pfizer Pharmaceuticals-Guayama and the School of Pharmacy of the Medical Sciences Campus, University of Puerto Rico, sponsored the award. Luis is currently a CBE PhD student in microbiology and a Molecular Biosciences Program Fellow.
 MSU Awards for Excellence

Awards for Excellence

Forty of Montana State University's top seniors and their faculty or staff mentors were recognized Tuesday, February 22, at the 29th annual Awards for Excellence banquet held on the MSU campus. The MSU Alumni Association and the Bozeman Chamber of Commerce sponsored the banquet.

Honored students were nominated by faculty in their college or department. Qualified seniors must have at least a 3.5 grade point average on a 4.0 scale as well as demonstrated campus leadership and community service. In turn, the award-winning students each selected a mentor who will be honored with them at the event. Two CBE students were honored:

Loribeth Evertz, mechanical engineering / Mentor: **Sarah Codd**

Hilary Fabich, chemical and biological engineering / Mentor: **Joseph Seymour**

2011 W.G. Characklis Award

Mari Eggers and **Anitha Sundararajan**, both PhD students in microbiology, were presented with the 2011 W.G. Characklis Outstanding Student Award Tuesday, February 8. The WG Characklis Award is presented annually to a CBE doctoral student for his or her contributions to research and education. The award honors Center Founder Bill Characklis, who envisioned students working on interdisciplinary teams, participating in innovative educational programs, interacting with industry, and assuming leadership roles.

Mari Eggers, a PhD student in microbiology, was recognized for her dedication to community-based participatory research on water quality and the health of the Crow Reservation community; exceptional service to students of Little Big Horn College; involvement with MSU's research initiatives partnering with Native Americans; and contributions to publications, committee service, and presentations.

Anitha Sundararajan, a PhD student in microbiology, was awarded in recognition of her original science at the interface between biofilms and microbial physiology; hard-working attitude, willingness to help others and to be a team player; and contributions to Montana Biofilm Meetings and workshops.

Doctoral students earn two of only twelve positions in the US-EC course on Environmental Biotechnology

Two CBE doctoral students, **Tisza Bell**, PhD student in microbiology, and **Robert Gardner**, PhD student in chemical and biological engineering, earned two of only twelve positions in the 2011 US-EC course in Environmental Biotechnology in Lausanne, Switzerland. The two-week course in July 2011 is designed to train early career scientists in state-of-the-art theoretical and practical aspects of microbial environmental biotechnology. The 2011 central topic is 'Microbial Catalysts for the Environment' and emphasizes identification and selection of microbial strains suitable for environmental application. This course is limited to 24 students, 12 from each side of the Atlantic, at the level of studying for a PhD degree or in the early phase of postdoctoral study. Additionally, both students were granted a fellowship to cover the course costs.

Tisza and Robert are both members of the MSU Algal Biofuels Group, NSF IGERT fellows, and work at MSU's Center for Biofilm Engineering (CBE). Their primary research is on algal physiology and isolation of algae for biofuel production. Both students are mentored by Brent Peyton, professor of chemical and biological engineering, and Robert is co-mentored by Keith Cooksey, research professor of microbiology.

NSF fellowship award

Luis O. Serrano Figueroa was awarded an 8-week fellowship to the National Science Foundation's **East Asia and Pacific Summer Institutes Program** in Palmerston North, New Zealand. Luis will be conducting biofilm research at Massey University under the supervision of Dr. Bernd Rehm. The East Asia and Pacific Summer Institutes' (EAPSI) goals are to introduce U.S. graduate students to East Asia and Pacific science and engineering in the context of a research setting, and to help students initiate scientific relationships that will better enable future collaboration with foreign counterparts. Selected students participate in research experiences at host laboratories in Australia, China, Japan, Korea, New Zealand, Singapore, or Taiwan. Luis is currently a CBE PhD student in biology and a Molecular Biosciences Program Fellow.

Engineers Without Borders chapter recognized

Mentored by CBE faculty member **Otto Stein**, professor, civil engineering, Montana State University's student-led chapter of Engineers Without Borders (EWB at MSU) won one of four W.K. Kellogg Outreach Scholarship Awards.

The Association of Public and Land-grant Universities announced the regional award, which recognizes EWB at MSU for its work in bringing clean water to Kenyan schools. The recognition also puts the chapter in national competition with community outreach programs at three other universities—Michigan State University, Pennsylvania State University, and the University of Tennessee Knoxville—for the C. Peter Magrath University/Community Engagement Award. The Magrath award carries a \$20,000 prize.

CBE undergraduates in chemical and biological engineering who lead the EWB, MSU chapter, include: **Kiera McNelis**, president; **Joseph Thiel**, vice-president; and **Bryan Vadheim**, treasurer.

Baking soda dramatically boosts oil production in algae

November 12, 2010 -- By Evelyn Boswell, MSU News Service

BOZEMAN -- Montana State University researchers have discovered that baking soda can dramatically increase algae's production of the key oil precursors for biodiesel.

The same ingredient that causes cookies to rise in the oven, the same agent that calms upset stomachs and removes odors from refrigerators is the elusive chemical trigger that scientists have sought since the early 1990s, said **Rob Gardner**, an MSU graduate student in chemical and biological engineering and a native of Afton, Wyo.

When added at a particular time in the growing cycle, baking soda more than doubled the amount of oil produced in half the time in three different types of algae. "It took a lot of work. I was pretty thrilled when it all came together," Gardner said. "I'm still kind of in shock about it."

Gardner is part of the team that developed the algal biofuel technology that MSU is now offering for licensing. Other members are longtime algae experts -- Keith Cooksey, research professor emeritus in microbiology, and **Brent Peyton**, professor in chemical and biological engineering, an associated faculty member of the Center for Biofilm Engineering, and associate director of MSU's Thermal Biology Institute.

The search for a chemical trigger to boost oil production in algae was a long, sometimes torturous, journey, according to the three MSU scientists. Not only did they have to find a chemical that would work, but they had to figure out the best time to add it to the algae. Cooksey taught Gardner how to grow the algae they used in their experiments. Gardner grew the algae in beakers and tubes in three labs across campus. He then conducted experiments and shared his progress with Cooksey and Peyton. Gardner worked for about 1 1/2 years before the trio confirmed that baking soda was the chemical trigger they'd been seeking. They made their initial discovery in two kinds of brown algae and one type of green.

"It was a lot of trial and error and failure," Gardner said. "We finally came across the right combination."

Cooksey said baking soda may work because it gives algae extra carbon dioxide necessary for its metabolism at a key point in its life cycle. If the baking soda is added too early or too late, the algae don't respond. But when added at just the right time in the growth cycle, algae produce two to three times the oil in half the time of conventional growth models. The oil, or lipid, is composed of triacylglycerides, the key precursors to biodiesel and biojet fuel. "For industry, if you double your output in half the time, that's a big deal," Cooksey said.

Reducing the amount of time needed to produce oil is also good because algal-producing ponds are prone to contamination, he added. If growers can produce oil faster, they can reduce the opportunity for contamination to ruin the product.

Peyton said the three types of algae used in the MSU study were not closely related, so the MSU discovery should have broad application. "We are working on demonstrating this in other varieties," he said.

Peyton and Cooksey said the baking soda discovery demonstrated the value of interdisciplinary work on campus. "The ties between the chemical and biological engineering and microbiology departments have never been stronger," Peyton said. "We work so closely with so many of the microbiologists that it's a very good collaboration, very fruitful."

He added that algal biofuel is the "fastest moving area I have ever been involved with. It's hard to keep up with all the new developments."

EDUCATION:

CBE Seminar Series | Fall 2010
Montana State University, Roberts Hall 101, 4:10pm

Date	Speaker	Affiliation	Topic
2-Sep	First Week of Class	No seminar	No seminar
9-Sep	Presidential Inauguration	No seminar	No seminar
16-Sep	John Tobiason	Professor, Civil & Environ Eng.; Coordinator, Environ & Water Resources Eng Program	Simultaneous control of Fe,Mn, and DBPs for a challenging groundwater: physical, chemical and microbial aspects
23-Sep	Charles Werth	Professor, Civil & Environmental Eng, Univ. of Illinois, Urbana- Champaign	Pore-scale evaluation of mass-transfer limited reaction and biomass growth in model groundwater pore systems, and implications for in-situ bioremediation
30-Sep	Joe Seymour	Associate Professor MSU-CHBE; CBE	Magnetic resonance measurements of dynamics in porous media, gels and colloidal suspensions: What does any of this have to do with biofilms?
7-Oct	Bret Chisholm	Senior Research Scientist, Center for Nanoscale Sci & Eng, North Dakota State Univ	Research and development of bioactive surface coating using high-throughput methods
14-Oct	Rob Cramer	Assistant Professor, MSU-VMB	Molecular mechanisms of hypoxia adaptation and their relation to <i>Aspergillus fumigatus</i> virulence and antifungal drug resistance
21-Oct	Robert Miller	Professor, Microbiology & Molecular Genetics, Oklahoma State Univ.	Sex, drugs, and penguins: Antibiotic resistance in the Antarctic
28-Oct	Pat O'Brien and Caryl Perdaems	RN, CWOCN, Clinical Coordinator; and OTR, CLT-LANA, CWS, Wound Clinic Manager; Wound Clinic, Bozeman Deaconess Hospital	A wound clinic's approach to chronic wound care
4-Nov	Christine Foreman	Assistant Research Professor MSU-LRES; CBE	Life in icy environments
11-Nov	Veteran's Day	No seminar	No seminar
18-Nov	Sabrina Behnke	Graduate Student- Microbiology- MSU	Comparing the disinfection of planktonic cells, biofilms and detached biofilm particles in single species and dual species cultures
25-Nov	Thanksgiving	No seminar	No seminar
2-Dec	Florence Mus	Post-Doc-MSU	Lipid-derived biofuels: Determination of factors that control triglyceride accumulation in microalgae
9-Dec	Last week of classes	No seminar	No seminar

EDUCATION:

CBE Seminar Series: Spring 2011

Date	Speaker	Affiliation	Topic
13-Jan	No Seminar-First Week of Classes		
20-Jan	Rob Gardner	PhD Candidate, Chemical and Biological Engineering Department, CBE	A simple chemical trigger for inducing triacylglycerol accumulation in algae
27-Jan	Pre-Montana Biofilm Meeting (Wednesday, January 26 th , 2011)		
3-Feb	Dr. Trond Møretrø	Research Scientist, The Norwegian Institute of Food, Fisheries and Aquacultural Research	Bacteria in the food industry: Biofilm, survival and control
10-Feb	Montana Biofilm Science & Technology Meeting		
17-Feb	Dr. Recep Avci	Research Professor, MSU-ICAL, Department of Physics	Tethering and nanoscale manipulation of living bacteria
24-Feb	Erin Field	PhD Candidate, Department of Microbiology, CBE	<i>Cancelled due to illness</i>
3-Mar	Dr. Jeff Heys	Assistant Professor, Chemical and Biological Engineering	Application of computational fluid dynamics to biofilms and other biological systems
10-Mar	Gem Encarnacion	PhD Candidate, Department of Microbiology, CBE	Characterization of simulated premise plumbing: A look into the microbial community
17-Mar	No Seminar-Spring Break		
24-Mar	Dr. Duane Moser	Associate Research Professor, DRI-Nevada System of Higher Education	Role of microbes in contaminant alteration and transport
31-Mar	Elliot Barnhart	Masters Candidate, Department of Microbiology, CBE	Analysis of methane producing communities within underground coal beds
7-Apr	Dr. Susan Lehman	PhD, Microbiologist, Georgia Institute of Technology, Centers for Disease Control	"CAUTI" – Catheter-Associated Urinary Tract Infection
14-Apr	Dr. Brian D. Wood	Associate Professor, Chemical, Biological and Environmental Engineering, Oregon State University	Transport of microorganisms in porous media from a multiscale perspective
21-Apr	<i>Traded for special time slot, May 2</i>		
28-Apr	Last Week of Classes		
2-May	Dr. Thomas Bjarnsholt	Associate Professor, Dept. of International Health, Immunology, and Microbiology, University of Copenhagen, Denmark	When bacteria aggregate. . . Biofilms in chronic wounds and the cystic fibrosis lung

TECHNOLOGY TRANSFER:
Industrial Associates, 2010–11

3M
Agile Sciences*⁺
BASF
Bausch & Lomb
Baxter Healthcare
Bayer MaterialScience
BD Medical
Bridge Preclinical Testing Services*
CareFusion (formerly Cardinal Health)
Church & Dwight Company
Colgate-Palmolive
Covidien
Dow Microbial Control
Embro Corporation*
ExxonMobil⁺
Glanbia Nutritionals
ICU Medical
Johnson & Johnson Consumer and Personal Products
Kane Biotech*
Kimberly-Clark
Masco Corporation
NASA
Novozymes A/S
Procter & Gamble
Reckitt Benckiser⁺
Sandia National Laboratories
Semprus BioSciences*
STERIS⁺
The Sherwin-Williams Company
Unilever
W.L. Gore & Associates
WuXi AppTec*

*indicates small business members

⁺indicates new members in reporting period

TECHNOLOGY TRANSFER:
Technical Advisory Conference
July 12–15, 2010

Monday, July 12

6:00–8:30 p.m.

Pre-registration and welcome reception

Hilton Garden Inn, Bozeman

Tuesday, July 13

7:30–8:00 a.m.

Registration and continental breakfast

Hilton Garden Inn reception area

8:00–8:15

Introductory remarks

Larkspur Ballroom

Paul Sturman, CBE Industrial Coordinator

Bill Schwingel, TAC Chair, Masco Corp.

Phil Stewart, CBE Director

SESSION 1:

Ophthalmologic Biofilms

8:15–8:45

Biofilms and ocular infections

Phil Stewart

8:45–9:25

Microbial biofilms, contact lenses, and contact lens care products

Tim Morris, Senior Principal Scientist, Global Development R&D

Microbiology, Bausch & Lomb, Rochester, NY

9:25–10:05

Contact lens-associated biofilms:

Model development and recent advances

Pranab Mukherjee, Assistant Professor, Center for Medical Mycology, Case Western Reserve University, Cleveland, OH

10:05–10:45 **Networking Break**

SESSION 2:

Biofilm Fundamentals

10:45–11:15

Physiological roles of a *Shewanella oneidensis* MR-1 PAS protein involved in oxygen consumption, transfer to anoxia, and biofilm formation

Anitha Sundararajan, PhD Candidate, Microbiology, CBE

11:15–11:45

Factors affecting biofilm formation by *Desulfovibrio vulgaris* Hildenborough

Andrew Sabalowsky, Postdoctoral Research Associate, CBE

11:45–12:45

Lunch catered at the Hilton Garden Inn

SESSION 3:

Biofilms in the Built Environment

12:45–12:50

Session introduction

Darla Goeres, Assistant Research Professor, CBE

12:50–1:20

The house as a system: How it impacts moisture in buildings

David Bell, Director of Building Science, Masco Contractor Services

1:20–1:50

Development of filamentous fungal biofilms

Julia Kerrigan, Assistant Professor, Mycology, Clemson University, Clemson, SC

1:50–2:20

Fungal biofilms associated with commercial carpet tile: Aspects of preservation, sanitization and recycling contaminants

Daniel Price, Director, Microbiology, InterfaceFLOR R&D

2:20–2:50

Biofilms on exterior painted surfaces: What grows and why

Gary Horacek, Director, Technical Microbiology Services, Troy Corp.

2:50–3:20 **Break**

3:20–3:50

Microbial colonization of nonporous surfaces in a workplace and residential indoor environment

Jayne Morrow, Environmental Engineer, Biochemical Science Division, NIST

3:50–4:20

The lungs of our built environments: The hunt for biofilms and beyond

W. Curtis White, President, White IEQ Consultants, LLC

4:20–4:45

Biofilms in premise plumbing

Anne Camper, Professor, Civil Engineering, CBE

4:45–5:10

***Legionella* and other microorganisms in biofilms from a hot water system**

Barry Pyle, Research Professor, Microbiology, MSU

Wednesday, July 14

7:30–8:00 a.m.

Registration and continental breakfast

Hilton Garden Inn reception area

SESSION 4:

Biofilm Methods

8:00–8:05

Session introduction

Darla Goeres

8:05–8:35

Anti-fouling betaine modifications for medical devices and industrial application

Christopher Loose, Chief Technology Officer, Semprus Biosciences

8:35–9:05

Use of laser capture microdissection to characterize biofilm heterogeneity

Mike Franklin, Associate Professor, Microbiology, MSU

9:05–9:35

FISHing in biofilm: Advanced in situ molecular techniques and 3D image analysis

Kristen Brileya, PhD Candidate, Microbiology, CBE

9:35–10:05

Healthcare-related pathogen disinfection and survival in a four-species potable water biofilm

Margaret Williams, Research Microbiologist, Centers for Disease Control and Prevention

10:05–10:35 Break

10:35–11:00

Biofilm efficacy test: Validation of the single tube protocol

Kelli Buckingham-Meyer, Research Assistant, CBE

11:00–11:30

Statistically assessing limits of detection and performance standards

Albert Parker, Biostatistician and Research Engineer, CBE

11:30–12:00

Development of a biofilm coupon holder and sampling test kit

Kevin Cook, Assistant Professor, Mechanical and Industrial Engineering & CBE, MSU

12:00–1:00

Lunch catered at the Hilton Garden Inn

Special Presentation

1:00–1:30

State of the CBE Address

Phil Stewart

1:30–2:30

CBE Business Meeting

3:00–5:00

Poster Session & Laboratory Open House

CBE Laboratories, 3rd Floor EPS Building, MSU

6:00–9:00 Dinner

Catered at Rockin' TJ Ranch, Bozeman

Thursday, July 15

7:00–8:00 a.m.

Biofilm Methods Advisory Committee Meeting

Darla Goeres and Paul Sturman

7:30–8:00 a.m.

Continental breakfast

Hilton Garden Inn reception area

SESSION 5:

Wound Biofilms

8:00–8:30

Recent advances in the characterization of human chronic wound biofilm

Anne Han, Wound Fellow, Department of Dermatology, Johns Hopkins Bayview Medical Center

8:30–9:00

Chronic wound healing in biofilm-challenged diabetic mice

Ge Alice Zhao, Senior Fellow, Division of Dermatology, Department of Medicine, University of Washington

9:00–9:30

Defining the impact of microbes in chronic wounds: A biofilm reactor

Hamed Motlagh, MPH Candidate, West Virginia University

9:30–10:00

Wound biofilm research at the CBE

Garth James, Medical Projects Manager, CBE

10:00–10:30 Break

SESSION 6:

Systems Analysis of Biofilms

10:30–11:00

Molecular level in silico analysis of mass and energy flows in microbial communities

Ross Carlson, Assistant Professor, Chemical and Biological Engineering, CBE

11:00–11:30

Characterization, classification, and analysis of undefined biofilm communities using molecular techniques

Brent Peyton, Professor, Chemical and Biological Engineering, CBE

11:30–12:00

Microbial community dynamics associated with different environments and processes

Matthew Fields, Assistant Professor, Microbiology, CBE

12:00–12:10

Meeting Wrap Up

TECHNOLOGY TRANSFER:
 Montana Biofilm Science & Technology Meeting
 WORKSHOP AGENDA
 July 12, 2010

Laboratory Biofilm Growth Reactors:
Choices for real-world applications

- 8:30 – 8:45** **Welcome** – Phil Stewart, CBE Director **EPS 323**
- Group introductions
- 8:45 – 9:00** **An Introduction to Biofilms** – Paul Sturman **EPS 323**
- 9:00 – 9:30** **Standardized Biofilm Methods** – Darla Goeres **EPS 323**
- 9:30 – 9:45** **Morning Refreshments**
- 9:45 – 10:15** **Importance of Statistical Design and Analysis** – Al Parker **EPS 323**
- 10:15 - 11:45** **Biofilm Reactors: The ‘right’ tool for the job** – **EPS 301, 316 & 326/7**
 – Diane Walker, Lindsey Lorenz, Kelli Buckingham-Meyer, Dan Shaughnessy, Dayla Morris, Alessandra Agostinho, Pat Secor, Jeremy Woods
- 11:45 - 1:00** **LUNCH** – Habit Restaurant, MSU Campus

Afternoon Laboratory Rotations:

	<u>Group 1</u>	<u>Group 2</u>	<u>Group 3</u>	<u>Group 4</u>
1:00 – 1:45	A	B	C	D
1:45 – 2:30	B	C	D	A
2:30 – 3:15	C	D	A	B
3:15 – 4:00	D	A	B	C

- A.** Scanning Electron Microscopy – Steve Fisher **ICAL EPS 339**
- B.** “FISHing” in Biofilm – Kristen Brileya **EPS 336**
- C.** Antarctic Biofilms – Heidi Smith **EPS 326/7**
- D.** Exploring the Potential of Algal Derived Biofuel – Rob Gardner, Everett Eustance, Karen Moll **Cobleigh 401 & EPS 326/7**

4:00 – 4:30 **Wrap-Up/Discussion** – **EPS 323**

TECHNOLOGY TRANSFER:
Technical Advisory Conference
February 8–9, 2011

Monday, February 7

6:00–8:30 p.m.
Pre-registration and welcome reception
 Hilton Garden Inn, Bozeman

Tuesday, February 8

7:30–8:00 a.m.
Registration and continental breakfast
 Hilton Garden Inn reception area

8:00–8:10
Introductory remarks
 Larkspur Ballroom
 Paul Sturman, CBE Industrial Coordinator
 Harsh Trivedi, TAC Chair, Colgate-Palmolive
 Phil Stewart, CBE Director

SESSION 1:
Novel Antimicrobials

8:10–8:15
Session introduction
 Phil Stewart, CBE Director

8:15–8:45
Next-gen antimicrobial strategies enabled by synthetic biology
 Michael Koeris, President, Novophage Therapeutics, Inc.

8:45–9:15
Surface active systems afford insights for biofilm control agents
 Joe Sauer, Senior R&D Advisor, The Albemarle Corporation

9:15–9:45
Research and development of antimicrobial coatings using combinatorial/high-throughput methods
 Bret Chisholm, Senior Research Scientist, Center for Nanoscale Science and Engineering; Director, Combinatorial Materials Research Laboratory, NDSU

9:45–10:15 Break

10:15–10:45
Antibacterial properties of cold electrically generated plasma and of plasma treated materials
 Gary Friedman, Professor, School of Biomedical Engineering, Drexel University

10:45–11:10
The surprising biological activity of volatile organic compounds from *Muscodor* spp.
 Gary Strobel, Professor Emeritus, Plant Sciences and Plant Pathology, MSU

SESSION 2:
Biofilm Methods

11:10–11:35
Chlorine and chlorine dioxide: Comparing the disinfection of detached biofilm particles
 Sabrina Behnke, PhD candidate, Microbiology, CBE

11:35–12:00
Update on the validation of a biofilm disinfectant efficacy test
 Darla Goeres, Assistant Research Professor, CBE

12:00–1:00
Lunch catered at the Hilton Garden Inn

SESSION 3:
Energy Related Biofilms

1:00–1:10
Session introduction
 Al Cunningham, Professor, Civil Engineering

1:10–1:25
MSU energy research
 Lee Spangler, Director, The Energy Research Institute, MSU

1:25–1:50
Characterization of algal triacylglycerol accumulation for biodiesel production
 Brent Peyton, Professor, Chemical and Biological Engineering, CBE

1:50–2:15
***Ascocoryne sarcoides*: Exploration of potential fuel production**
 Natasha Mallette, PhD candidate, Chemical & Biological Engineering, CBE

2:15–2:40
Utility of biofilms and biologically induced mineralization in geologic carbon sequestration
 Robin Gerlach, Associate Professor, Chemical & Biological Engineering, CBE

Poster Session & Laboratory Open House

3:20–5:20
 CBE Laboratories, 3rd Floor EPS Building, MSU

Wednesday, February 9

7:30–8:00 a.m.
Registration and continental breakfast
 Hilton Garden Inn reception area

SESSION 4:
Biofilm Imaging/ Microscopy

8:00–8:25
Optical microscopy of biofilms: The pursuit of more relevant imaging conditions
 Betsey Pitts, Research Associate and Microscope Facilities Manager

8:25–8:50
Nanoscale manipulation by immunoimmobilization of *living* bacteria
 Recep Avci, Director of Imaging and Chemical Analysis Laboratory (ICAL) and Research Professor, Physics, MSU

8:50–9:20
In situ measurement of biofilm activity by FISH: Implications for the therapy of infective endocarditis
 Judith Schmiedel, Institute for Microbiology and Hygiene, Charité University Hospital, Berlin

SESSION 5:

Healthcare Related Biofilms

9:20–9:50

In vitro and in vivo testing of antimicrobial central venous catheters

Garth James, CBE Medical Projects
Manager and Associate Research
Professor, ChBE

9:50–10:20 Break

10:20–10:50

Bacterial inter-species interactions in multispecies biofilm communities

Alex Rickard, Assistant Professor of
Biological Sciences, University of
Michigan

10:50–11:20

Urinary conditioning film components—A new target for preventing bacterial biofilm formation on urinary devices

Dirk Lange, Assistant Professor of
Urology, Department of Urologic
Sciences, University of British
Columbia, Vancouver, BC, Canada

11:20–11:50

SaeR/S-mediated regulation of *hla* promotes USA300 pathogenesis

Tyler Nygaard, Postdoctoral
Researcher, Veterinary Molecular
Biology, MSU

11:50–12:00

Meeting Wrap-up

TECHNOLOGY TRANSFER: NEWS

Knowledge Sharing Articles on Standardized Methods

Since May 2010, the Center for Biofilm Engineering has been publishing a series of articles written by Professor Marty Hamilton, professor emeritus of statistics, and Al Parker, CBE research engineer and biostatistician. This series of Knowledge Sharing Articles is being written with the purpose of disseminating information that is the topic of presentations, posters, workshops or discussions that occur at the CBE. Each Knowledge Sharing Article is a concise discussion on a specific topic. The information is not peer reviewed, in the traditional sense, but these concepts have been debated, tested, refined and used at the CBE. Within one series, the terms and concepts will build on each other, similar to the way concepts are presented in a college course, implying that it is best to read the articles sequentially. These articles will be a part of the CBE newsletter and archived on the CBE web site.

The first series is titled **Testing Surface Disinfectants**. The articles are listed below, in their logical order.

1. An introduction
2. Quantitative, semi-quantitative, qualitative, and alternative methods
KSA-SM-02.pdf (68.77 kB)
3. Desirable attributes of a standardized method
KSA-SM-03.pdf (114.69 kB)
4. Method development phases
KSA-SM-04.pdf (51.71 kB)
5. How the differences between disinfectant tests and chemical assays affect method evaluation criteria
KSA-SM-05.pdf (71.33 kB)
6. Enumerating viable cells by pooling counts for several dilutions
KSA-SM-06.pdf (194.16 kB)
7. The log reduction (LR) measure of disinfectant efficacy
KSA-SM-07.pdf (64.24 kB)
8. The P/N formula for the log reduction when using a semi-quantitative disinfectant test of type SQ1
KSA-SM-08.pdf (85.29 kB)
9. Importance of checking whether the harvesting and disaggregating steps bias the results of a surface disinfectant test
KSA-SM-09.pdf (83.08 kB)
10. Assessing resemblance, repeatability, and reproducibility for quantitative methods
KSA-SM-10.pdf (168.53 kB)

ASTM Committee approves fourth biofilm method

Method E2799-11, titled "Standard Test Method for Testing Disinfectant Efficacy against *Pseudomonas aeruginosa* Biofilm Using the MBEC Assay™," was approved during the April 2011 E35 committee meeting in Anaheim, CA. The purpose of this test method is to direct a user in how to grow, treat, sample, and analyze a *Pseudomonas aeruginosa* biofilm using the MBEC Assay™. The MBEC Assay™ was designed by Innovotech, Inc. as a rapid and reproducible assay for evaluating biofilm susceptibility to antibiotics (MBEC stands for "minimum biofilm eradication concentration"). The engineering design allows for simultaneous evaluation of multiple test conditions, making it an efficient method for screening multiple disinfectants or multiple concentrations of the same disinfectant. The standardization of the method was a joint effort between Innovotech, Inc. and the Center for Biofilm Engineering Standardized Biofilm Methods Laboratory.

This is the 4th method approved by ASTM that the Center for Biofilm Engineering has helped develop since 2002. The previous three methods include:

- E2647 Drip Flow Reactor Method, approved in 2008
- E2562 CDC Biofilm Reactor Method, approved in 2007
- E2196 Rotating Disk Reactor Method, approved in 2002

OUTREACH:

Visiting researchers

Debora Barbosa, DDS, visited from the Universidade Estadual Paulista (UNESP) in Brazil for two weeks in February 2011. Dr. Barbosa had recently finished her postdoctoral work at the University of Calgary studying the effect of silver nanoparticles against *Candida* species biofilms grown in MBEC plates. At the CBE, she worked with **Alessandra Agostinho** to test her nanoparticles against *Candida albicans* biofilms grown in CBE reactors.

Mery de la Fuente was invited by **Anne Camper** as a visiting researcher from the University of Concepción in Chile, where she is a PhD student working with Dr. Homero Urrutia Briones. During her three-month stay at the CBE (July–September 2010), she worked on learning how to grow biofilms in capillary flow cells and how to operate the confocal scanning laser microscope.

Anozie Ebigo, postdoctoral researcher at the University of Stuttgart, Germany, continued collaborative work with **Al Cunningham** for six weeks in May and June, 2010.

Megan Elam, a masters student in microbiology from Oregon State University (OSU) in Corvallis, was a visiting researcher at the CBE for the month of July 2010, working with CBE student **Steve Bugni**. Megan works for Rick Colwell, from the College of Oceanic and Atmospheric Sciences at OSU, is collaborating on a DOE Subsurface Biogeochemical Research Program grant with CBE faculty member **Robin Gerlach**. The grant focuses on understanding the influence of biofilms and minerals on transport and mixing in porous media. Dr. Colwell was a lecturer for the Ocean Leadership Distinguished Lecturer Series and visited MSU in March.

Marion Fontagneu, a visiting masters candidate in microbiology from the Université de Pau, France, worked with **Anne Camper** from March 2010 through September 2010.

Buntu Godongwana, a Fulbright Visiting Researcher, came to do research at the CBE from August 2010 to August 2011, working with **Phil Stewart**. Buntu is a PhD candidate in chemical engineering at the Cape Peninsula University of Technology in South Africa. His research focuses on membrane bioreactors.

Mijeong Jang, a visiting postdoctoral scientist from Seoul, Korea, was invited by faculty member **Anne Camper** to work at the CBE starting in January 2010 in the Industrial & Environmental Water Systems laboratory with **Mark Burr**. Dr. Jang has an interest in the effects of humics on biofilms in drinking water distribution systems.

Irina Khilyas, a PhD student in microbiology at Kazan State University in Russia, came to the CBE in January 2011, with plans to work in **Robin Gerlach**'s research group through December. Irina has been working with Ayrat Ziganshin (a CBE collaborator, also from Kazan State University) on research investigating the transformation of TNT by yeasts. Ayrat was a visiting Fulbright scholar at the CBE in 2004/2005. Irina is continuing and expanding on some of Ayrat's work.

Danielle Kinsey, an undergraduate student in microbiology at Fort Belknap College, came to the CBE for the summer of 2010 to study biofilms with **Kristen Brileya** and **Matthew Fields** as part of the American Indian Research Opportunities (AIRO) BRIDGES program.

Emma Mean, visiting undergraduate from Notre Dame University, was invited by faculty member **Christine Foreman** to study at the CBE from June 2010 through August 2010. This was her second summer working at the CBE.

Fidel Martínez Gutiérrez, Universidad Autónoma de San Luis Potosí, San Luis Potosí, México, visited the CBE from May 2–14, 2011. Dr. Gutiérrez worked with Garth James in the Medical Biofilm Laboratory on the anti-biofilm activity of silver nanoparticles.

Trond Møretro is a research scientist on sabbatical leave from Nofima Food (formerly the Norwegian Food Research Institute) in Ås, spending nearly a year at the CBE working in **Phil Stewart**'s Biofilm Control Laboratory. Trond is a food microbiologist and is interested in expanding his capabilities for working with biofilms.

Sai Nagarajan, a postdoctoral researcher from the University of Montana, Missoula, visited **Mike Franklin**'s lab during the month of October 2010.

Annika Rieder and **Silke Kirchen**, Karlsruhe Institute of Technology, Karlsruhe, Germany, visited the CBE August 30–September 2, 2010, with interests in 1) methods for growing, treating, sampling and analyzing biofilm bacteria, 2) biofilm control strategies, and 3) medical biofilms.

Indra Sandal was a visiting research scientist at the CBE for a month (from July 19–August 20, 2010) from the Center for Molecular Medicine and Infectious Diseases, Virginia-Maryland Regional College of Veterinary Medicine, Virginia Polytechnic Institute and State University. Her research focus is bovine respiratory disease. While at the CBE, Indra worked on optimizing the drip flow reactor for growing *Mannheimia haemolytica* and *Histophilus somni* biofilms. She was invited by **Darla Goeres**.

John Tobiason, professor in civil and environmental engineering at University of Massachusetts–Amherst, visited the CBE from mid-August to early October, 2010 as part of a sabbatical. Invited by **Anne Camper**, he focused on getting an overview of biofilms in environmental systems, with an emphasis on water and wastewater.

Dr. **Yi Wang**, invited by faculty member **Phil Stewart**, joined the Biofilm Control lab as a visiting scientist in May 2009 for 12 months. An associate professor at Xi'an University of Architecture & Technology in China, she has a PhD in environmental engineering. She came to study aspects of biofilm mechanics and cohesion, with the idea of connecting this work to her interest in water and wastewater engineering.

Visiting graduate student first authors

Most visiting students work at the CBE for a period of several months, while others, like Anozie Ebigo (now a postdoctoral researcher), have visited the CBE several times over a period of years as they collaborate with CBE researchers.

Cotter JJ, O'Gara JP, Stewart PS, Pitts B, Casey E, "Characterization of a modified rotating disk reactor for the cultivation of *Staphylococcus epidermidis* biofilm," *J Appl Microbiol*, 2010, 109(6):2105–2117.

Ebigo A, Helmig R, Cunningham AB, Class H, Gerlach R, "Modeling biofilm growth in the presence of carbon dioxide and water flow in the subsurface," *Advances in Water Resources*, 2010; 33:762–781.

Kim J, Hahn JS, Franklin MJ, Stewart PS, Yoon J, "Tolerance of dormant and active cells in *Pseudomonas aeruginosa* PAO1 biofilm to antimicrobial agents," *J Antimicrob Chemother*, 2009;63:129–135.

Villa F, Albanese D, Giussani B, Stewart PS, Daffonchio D, Cappitelli F, "Hindering biofilm formation with zosteric acid," *Biofouling*, 2010 Aug; 26(6):739–52.

OUTREACH:

Tours and visits

CBE research team visits Hardin Intermediate School: Brent Peyton's algal research team participated in the "Science is Cool" field trip for the Hardin Intermediate School 4th graders Thursday, March 31. The students gained valuable hands-on experience as they learned how algae can be used for producing biofuels.

Seventeen Japanese high school students touring Yellowstone and Glacier National Parks with Yellowstone Glacier Adventures visited the CBE on July 29, 2011. **Gem Encarnacion**, PhD student, microbiology, led the group on a lab tour, highlighting the various environmental and medical applications of CBE research, including using algae to produce biofuels. The group was interested to see the types of biofilm we work with, and how we grow and test them.

Ann Willis, CBE Technical Operations Manager, led a CBE lab tour for fifteen advanced placement biology students from Belgrade and Three Forks high schools. The students asked lots of questions as they toured the bioprocess and algal biofuel labs and viewed biofilm images and cryosectioning through CBE microscopes. We look forward to their return as biofilm researchers in the future.

High school and middle school students from three Montana cities—Colstrip, Lincoln and Bozeman— visited the CBE in April 2011. **Ann Willis**, CBE Technical Operations Manager, and **several CBE undergraduate and graduate students** conducted lab tours for students from Colstrip High School, Bozeman High School, and Lincoln's middle and high schools. **Elliott Barnhart, Rob Gardner, Everett Eustance, and Laura Bickle** showed students a few labs and gave a series of highlights regarding some of the research we do here at the Center. **Alissa Bleem, Gem Encarnacion, and Rachel VanKempen-Fryling** served as ambassadors, guiding the students to each of the stations and answering questions along the way. With an interest in studying science at the college level, the high school students were full of questions and observations as they toured the bioprocess and algal biofuel labs and viewed biofilm images and cryosectioning through CBE microscopes. Lincoln's middle school students were visiting campus as part of the school's initiative to introduce college to 7th and 8th-grade students to pique their interest in seeking higher education.

Web image library use

This was the first full year of use of the Drupal automated image request system. There were **486** image downloads; **53 out of 54 images** were downloaded.

The most frequently downloaded graphic was "**Biofilm formation in 3 steps** (nid 2311)." Rounding out the top ten were:

2. Sites of primary and secondary infection (nid 2388)
3. Biofilm formation basics (nid 2298)
4. Biofilm migration (nid 2313)
5. Cell-cell communication (nid 2321)
6. Dental inflammation (nid 2378)
7. Biofilms impact human health and industries (nid 1276)
8. Biofilm structure with labels (nid 2302)
9. Complexity of biofilms (nid 2309)
10. Biofilm structure simplified (nid 2305)

There were **251** Academic [general K-12 & Higher Ed] downloads, **187** Academic [medical/dental], **63** Industry/Business, and the rest were Federal or State Agency or Other requests. A huge majority of requests were for image use in **presentations**, followed by use in **theses**. These submission results are consistent with the intent that the images are posted for educational use.

Requests for CBE graphics use were submitted from **30** of the United States, by **90** requesters:

Alabama	Illinois	Minnesota	New York	Wisconsin
Arizona	Iowa	Montana	Ohio	Wyoming
California	Kentucky	Nebraska	Oregon	
Colorado	Louisiana	New Hampshire	Pennsylvania	
Connecticut	Maryland	New Jersey	South Carolina	
Florida	Massachusetts	North Dakota	Texas	
Georgia	Michigan	New Mexico	Virginia	

There were **191** requests from an additional **36** countries:

Argentina	Czech Republic	Indonesia	Mexico	Sweden
Australia	Denmark	Iran	New Zealand	Switzerland
Brazil	Finland	Ireland	Norway	Taiwan
Canada	France	Israel	Poland	The Netherlands
Chile	Germany	Italy	Portugal	Turkey
China	Greece	Japan	South Korea	United Kingdom
Croatia	India	Jordan	Spain	Vietnam

FACILITIES:

Center for Biofilm Engineering Facilities Overview

The CBE moved into the MSU's Engineering/Physical Sciences Building when it opened in 1997. The >20,000 ft² facility includes offices and conference rooms for faculty, staff, and students; two computer laboratories; and thirteen fully equipped research laboratories. The full-time CBE Technical Operations Manager oversees research laboratories, provides one-on-one training for students, ensures safe laboratory practices, and maintains equipment. State-of-the-art instruments and equipment are available for use by all CBE faculty, staff, and students. General use areas include a microbiology lab, a media kitchen, an instrument lab, and an isolated radioactive isotope lab. Facilities of particular note are described below.

Mass spectrometry facility

In 2005 an equipment grant was awarded for an Environmental and Biofilm Mass Spectrometry Facility through the Department of Defense University Research Instrumentation Program (DURIP). The grant funded the acquisition of an Agilent 1100 series high performance liquid chromatography system with autosampler and fraction collector, an Agilent SL ion trap mass spectrometer, and an Agilent 6890 gas chromatograph with electron capture detector, flame ionization detector, and 5973 inert mass spectrometer. Since then, an Agilent 7500ce inductively coupled plasma mass spectrometer with autosampler, liquid, and gas chromatographic capabilities has also been added. Mass spectrometers are very well suited for unknown compound identification and high sensitivity speciation measurements of organic and inorganic compounds; this equipment enhances the CBE's research capabilities significantly. The Environmental and Biofilm Mass Spectrometry Facility is operated as a user facility and allows access for academic and non-academic researchers.

Microsensor Laboratory

A specialized Microsensor Laboratory provides the capability of measuring microscale chemical and physical parameters within biofilms. The laboratory maintains a microsensor fabrication and testing area that includes electrode pullers, microscopes, and grinding machines. All of these electrodes are used in conjunction with computer-controlled micropositioners for depth profiling, and a computer-controlled x-y table for mapping parameters in a horizontal plane. The microsensor lab also has instrumentation for measuring corrosion and other electrochemical phenomena associated with biofilms.

Microscope Facilities

The CBE microscopy facilities are coordinated by the Microscopy Facilities Manager, who maintains the equipment and trains and assists research staff and students in capturing images of in situ biofilms via optical microscopy and fluorescent confocal microscopy. The microscopy facilities include three separate laboratories—the Optical Microscopy Lab, the Confocal Microscopy Lab, and the Microscope Resource Room and Digital Imaging Lab—which are detailed below.

The **Optical Microscopy Lab** houses two Nikon Eclipse E-800 microscopes, used for transmitted light and epi-fluorescent imaging of biofilms. We have a large collection of fluorescence filter cubes for the Nikons, including those optimized for the following fluorescent stains: FITC (gfp), TRITC (propidium iodide), DAPI, CTC, ELF-97, CY5, cfp, and we also have a B2E cube. Both Nikons are equipped with Nomarski/DIC. Both microscopes are equipped with cooled CCD fluorescent cameras, a video camera, and a color camera; they use Universal Imaging Corporation's MetaVue software for digital image acquisition. Images collected on the Nikons range from pictures of in situ biofilms as they accumulate over time on glass tubing to FISH (Fluorescence In Situ Hybridization)-probed, cryosectioned colony biofilms.

The Optical Microscopy Lab also includes a Nikon SMZ-1500 Stereo Zoom Microscope, with a magnification range from roughly 7.5 to 110X. The stereo scope gives researchers stunning, 3-dimensional views of biofilms on a more macroscopic scale than can be achieved with other microscopes. Finally, the lab includes a Zeiss Palm Laser Capture Dissection microscope, and a Leica CM 1850 cryostat, which is used to cut very thin sections (usually 5 micrometers) of frozen biofilm.

The **Confocal Microscopy Lab** contains two brand-new (2011) Leica SP5 Confocal Scanning Laser Microscopes (CSLMs).

One is an inverted confocal microscope with 405, 488, 561 and 633 nm laser excitation lines. It is equipped with a tandem scanner, so it can be switched from standard scanning mode to operate in Resonant Scanner

mode, which enables scanning at exceptionally high frequencies for fluorescent imaging. This faster scanning is necessary for most live cell imaging (note: “live cell imaging” doesn’t generally refer to imaging bacterial cells, but rather mammalian cells and processes). This inverted SP5 also includes a heated stage with an environmental control chamber (i.e. it can be used to provide an enclosed CO₂ atmosphere), and a motorized stage with Mark-and-Find and image tiling capabilities.

The second new SP5 is an upright confocal microscope, also with 405, 488, 561 and 633 nm lasers, a motorized stage, Mark-and-Find, and tiling capabilities. This upright has a removable heated chamber that encloses the entire microscope, so that larger, incubated flow cell systems can be accommodated over long periods of time. This enables high-resolution time-lapse monitoring of biofilm development, treatment and detachment phenomena. Additionally, this microscope is equipped with Fluorescence Lifetime Imaging (FLIM) capability, which is also referred to as Single Molecule Detection.

The CSLM is capable of imaging biofilms on opaque surfaces, so a wide variety of materials can be used in the experimental flow cells. As biofilm formation proceeds in an experiment, representative areas of the colonized surface are scanned with the use of the automatic stage. Digital data is collected from sequential scans, and stored data can be viewed in the x, y, z coordinates to yield a 3-dimensional image of the biofilm architecture. Quantitative and qualitative information about biofilm architecture can be retrieved easily from examination of CSLM data, in both the x-y and x-z planes, and the existence or absence of structural features, such as microcolonies and water channels, can be determined.

The **Microscope Resource Room / Digital Imaging Lab** is where CBE researchers examine and reconstruct the stacks of collected image data using our image analysis software. For quantitative analysis, such as intensity or particle-size measurements, we use Universal Imaging Corporation’s MetaMorph software. We use Bitplane’s Imaris software for qualitative analysis—for example, putting together a stack of 200 red and green flat images, to get a 3-dimensional image of a biofilm microcolony that can be rotated in space and examined from every angle. The lab consists of three dedicated computers, SCSI drives for storing large files, CD and DVD burners and readers, and a color printer. In addition to providing CBE students, staff, and researchers with an imaging workplace, the resource room gives us a place to hold group tutorials and WebEx group software training sessions.

Flow Cytometry Facility

The flow cytometry facility is available for research staff to investigate physical and/or chemical properties of disaggregated biofilm cells in suspension. This facility is an excellent complement to the microscope facility in that biofilms may be examined in situ under the microscope and then later disaggregated for single-cell examination in the flow cytometer. This instrument has a wide variety of uses from examining heterogeneous populations, to counting cells, to sorting specific populations within a sample.

The facility is equipped with a Becton Dickinson FACSAria flow cytometer. Housed with three lasers, a 405 nm, 488 nm and a 633 nm, the FACSAria is able to detect up to seven different fluorochromes, plus forward and side scatter simultaneously. High-speed sorting is also a feature of the FACSAria. Two- and four-way sorting can be performed as well as sorting into 96-well plates.

Computer Facilities

CBE staff and students have access to workstations connected to the MSU College of Engineering computer network. A student computer laboratory offers ten state-of-the-art PCs along with scanning and printing services. In addition, the COE maintains a computational cluster for data manipulation, mathematical modeling, and graphic image analysis.

SPECIALIZED CBE LABORATORIES

Medical Biofilm Laboratory

The Medical Biofilm Laboratory (MBL) has earned a reputation for being a university lab that responds quickly to real world needs in the area of health care as it relates to biofilms. Dr. Garth James (PhD, microbiology), Randy Hiebert (MS, chemical engineering) and Dr. Elinor Pulcini (PhD, microbiology) have been the innovative leaders and managers of this respected, flexible, and adaptable lab group. The MBL team also currently includes two full-time research scientists, three technicians, one graduate student, and two undergraduate research assistants.

Nine companies, including CBE Industrial Associates, currently sponsor MBL projects. Projects include evaluating antibiofilm technologies for chronic wounds, dental plaque, and bacterial vaginitis as well as testing antimicrobial medical devices. The MBL is also conducting basic preliminary research on chronic wounds and acne vulgaris in collaboration with clinical investigators. The MBL is a prime example of integration at the CBE, bringing together applied biomedical science, industrial interaction, and student educational opportunities.

Standardized Biofilm Methods Laboratory

The Standardized Biofilm Methods Laboratory (SBML) was designed to meet research and industry needs for standard analytical methods to evaluate innovative biofilm control technologies. SBML staff and students develop, refine, and publish quantitative methods for growing, treating, sampling, and analyzing biofilm bacteria. The SBML members work with international standard setting organizations to promote approval of biofilm methods by the standard setting community. Under a contract with the U.S. Environmental Protection Agency (EPA), the SBML conducted laboratory research to support the development and standardization of a test method for measuring the performance of antimicrobial products—including those for biofilm bacteria. Under this same contract, the SBML provided statistical services related to EPA's Office of Pesticide Programs Antimicrobial Testing Program. In addition, SBML staff conduct applied and fundamental research experiments and develop testing protocols. Methods include: design of reactor systems to simulate industrial/medical systems; growing biofilm and quantifying cell numbers and activity; testing the efficacy of chemical constituents against biofilms; and microscopy and image analysis of biofilms. SBML staff offer customized biofilm methods training workshops for CBE students, collaborators, and industry clients.

OTHER Montana State University facilities available for collaborative research

MSU Nuclear Magnetic Resonance (NMR) Facility

A state-of-the-art NMR facility is available on campus on a recharge basis for research projects. This facility is a 5-minute walk from the College of Engineering and CBE laboratories. All the instruments in the facility are Bruker Avance instruments. The facility houses 300, 500 and 600 MHz NMR instruments for high resolution spectroscopy analysis.

MSU Magnetic Resonance Microscopy (MRM) Facility

A state-of-the-art MRM facility is available on a recharge basis for research projects. This facility is located in the College of Engineering in the same building as the Center for Biofilm Engineering. Both instruments in the facility are Bruker Avance instruments. The facility houses 250 MHz standard/wide bore and a 300 MHz wide/super-wide bore instruments for imaging and fluid dynamics applications. The imaging systems are capable of generating NMR image and transport data with spatial resolution on the order of 10 μm in a sample space up to 6 cm diameter.

MSU ICAL Laboratory

The Image and Chemical Analysis Laboratory (ICAL) in the Physics Department at Montana State University is located on the 3rd floor of the EPS Building, adjacent to the Center for Biofilm Engineering. ICAL is a user oriented facility that supports basic and applied research and education in all science and engineering disciplines at MSU. The laboratory provides access to state of the art equipment, professional expertise and individual training to government and academic institutions and the private sector. Laboratory instrumentation is dedicated to the characterization of materials through high resolution imaging and spectroscopy. ICAL promotes interdisciplinary collaboration between the research, educational and industrial fields.

Current Instrumentation

- * Atomic Force Microscope (AFM)
- * Field Emission Scanning Electron Microscope (FE SEM)

- * Scanning Electron Microscope (SEM)
- * Small-Spot X-ray Photoelectron Spectrometer (XPS)
- * Time-of-Flight Secondary Ion Mass Spectrometer (ToF-SIMS)
- * X-Ray Powder Diffraction Spectrometer (XRD)
- * Scanning Auger Electron Microprobe (AUGER)
- * Epifluorescence Optical Microscope
- * Microarray Chip Writer and Reader System
- * Critical Point Drying
- * Video Contact Angle System

For more information on each system, see the ICAL web site at: <http://www.physics.montana.edu/ical/home/index.asp>