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# 2010 APPENDIX

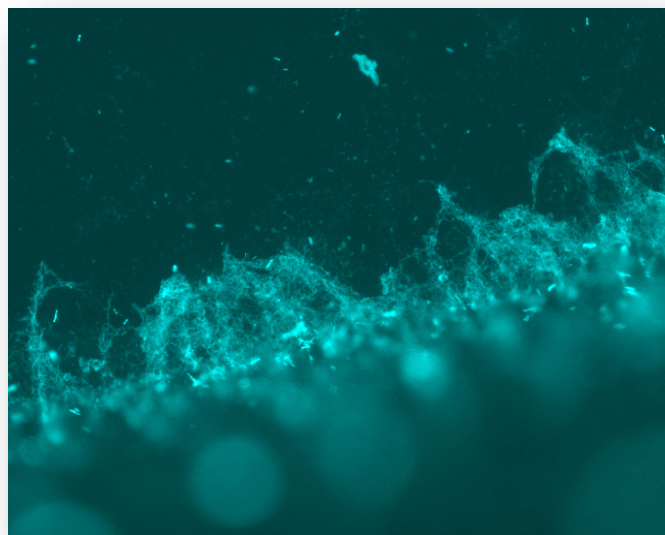
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## **Center for Biofilm Engineering**

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Montana State University  
Bozeman

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Microscope imaging by B Pitts

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RESEARCH:  
 CBE RESEARCH AREAS

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**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 by competitive grants and industrial memberships; and
- produces both fundamental and applied results.

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

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## APPLIED RESEARCH AREAS & PROJECTS

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

**Energy solutions** biofuels | microbial fuel cells

**Environmental subsurface technologies** bioremediation | wetlands | CO<sub>2</sub> 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:  
 2009–2010 CBE RESEARCH PROJECTS

Research Area	Title	Principal Investigator	Funding Agency
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	<sup>3</sup> Collaborative research: Integrated high resolution chemical and biological measurements on the deep WAIS divide core	Foreman	NSF
Education	Biofilms: The Hypertextbook	Cunningham Ross	NSF
Education	Partners in Science program	Pulcini	MJ Murdock Charitable Trust
Energy Solutions	Environmental responses to geologic CO <sub>2</sub> sequestrations	Cunningham	DOE EPSCoR
Energy Solutions	Basic science of retention issues, risk assessment & measurement, monitoring & verification for geologic CO <sub>2</sub> sequestrations	Cunningham	DOE-ZERT
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 <sub>2</sub>	Cunningham Spangler	DOE/ZERT
Environmental Technologies	<sup>2</sup> Mechanistically based field scale models of uranium biogeochemistry from up scaling pore-scale experiments and models	Seymour Codd	DOE
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	Seasonal, operational, and plant effects on oxygen potential and microbial responses influencing constructed wetland performance	Stein	USDA
Environmental Technologies	<sup>2</sup> Biocomplexity: Biogeochemical cycling of heavy metals in contaminated sediments at Lake Coeur d'Alene	Peyton	NSF
Environmental Technologies	Microbial activity and precipitation at solution-solution mixing zones in porous media	Gerlach	DOE-ERSP
Water Systems	Control of microbial processes for enhanced water treatment using Floating Island Treatment Systems	Camper Cunningham	MBRCT
Medical Biofilms	<i>Staphylococcus aureus</i> and production of toxic shock syndrome toxin	Lewandowski	Procter & Gamble
Medical Biofilms	Healing chronic wounds by controlling microbial biofilm	Stewart James	NIH
Medical Biofilms	Non-invasive clinical device that is effective in clearing persistent infections in prosthetic knee implants	McLeod	MTBRC
Medical Biofilms	Novel chemical analysis of the biofilm-biomaterial interface	Carlson	NIH via University of Illinois

Medical Biofilms	Development of bismuth-thiol based therapeutic agents for treating chronic wounds	Stewart	MBRCT
Methods Development	Antimicrobial test methodology	Goeres	EPA
Methods Development	Research support for standardizing a comprehensive biofilm efficacy test system	Goeres Cunningham	MBRCT
Modeling	CMG research	Klapper	NSF
Multicellular/ Extracellular	Cohesive strength & detachment of bacterial biofilms	Stewart	NSF via University of Minnesota
Physiology & Ecology	<sup>*1</sup> Role of non-coding RNAs in <i>P. aeruginosa</i> biofilm development	Franklin	NIH
Physiology & Ecology	Virtual Institute for Microbial Stress & Survival	Fields	Lawrence Berkley National Lab
Physiology & Ecology	Metabolic engineering of <i>Alicyclobacillus acidocaldarius</i> for lactic acid production from biomass derived monosaccharides	Carlson	Idaho National Lab
Water Systems	Crystal Richards EPA Fellowship	Camper	EPA
Water Systems	Effect of nitrification on corrosion in the distribution system	Camper	AwwaRF via Virginia Tech

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

<sup>1</sup>MSU Department of Microbiology

<sup>2</sup>MSU Department of Chemical and Biological Engineering

<sup>3</sup>MSU Department of Land Resources & Environmental Sciences

**List of Acronyms**

<b>AwwaRF</b>	American Water Works Association Research Foundation
<b>DOE</b>	U.S. Department of Energy
<b>EPA</b>	U.S. Environmental Protection Agency
<b>MSGC</b>	Montana Space Grant Consortium
<b>MBRCT</b>	Montana Board of Research and Commercialization Technology
<b>NASA</b>	National Aeronautics and Space Administration
<b>NIH</b>	National Institutes of Health
<b>NSF</b>	National Science Foundation
<b>ONR</b>	Office of Naval Research
<b>USDA</b>	U.S. Department of Agriculture
<b>ZERT</b>	Zero Emissions Research and Technology

**FY10 New CBE Research Grants**

**(July 1, 2009 - June 30, 2010)**

<b><u>Sponsor</u></b>	<b><u>Title</u></b>	<b><u>PI</u></b>	<b><u>Period</u></b>	<b><u>Amount</u></b>
NSF-ARRA	EFRI-HyBi:Fungal Processes for Bioconversion	Peyton	4 yrs.	\$1,998,849
NSF	CMG Research	Klapper	4 yrs.	\$750,002
<b>Total new grant awards to CBE for FY 2010</b>				<b>\$2,748,851</b>

RESEARCH:  
 CBE Associated Faculty and Their Specialties, 2009–2010

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 & Engineering Technology	Tool and machine design
Al Cunningham	Civil Engineering	Subsurface biotechnology and bioremediation
Jack Dockery	Mathematical Science	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	Statistics	Applied biostatistical thinking
Jeff Heys	Chemical & Biological Engineering	Fluid-structure interactions
Thom Hughes	Cell Biology & Neuroscience	Fluorescent proteins, genetically encoded biosensors
Garth James	Chemical & Biological Engineering	Medical biofilms
Warren Jones	Civil Engineering	Water distribution systems
Isaac Klapper	Mathematical Science	Mathematical modeling
Zbigniew Lewandowski	Civil Engineering	Microsensors, chemical gradients, biofilm structure
Bruce McLeod	Electrical & Computer Engineering	Bioelectric effect
Ahsan Mian	Mechanical Engineering	MEMs for mechanophysical measurements
David Miller	Mechanical & Industrial Engineering	Experimental mechanics
Andy Mitchell	Civil Engineering	Geomicrobiology
Al Parker	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	Mathematics	Mathematical modeling

RESEARCH:  
 PUBLICATIONS  
 June 2009–May 2010

2009 Publications

**Ammons MCB, James GA, Stewart PS**, “Letter to the Editor: Highlights from the Montana wound biofilm retreat,” *Wound Rep Reg*, 2009; 17(4):626-627. Abstract 09-024

**Aston JE, Apel WA, Lee BD, and Peyton BM**, “Toxicity of select organic acids to the slightly thermophilic acidophile *Acidithiobacillus caldus*,” *Environ Toxicol Chem*, 2009; 28(2): 279–286. Abstract 09-036

Dai T, Tegos GP, Lu Z, Huang L, Zhiyentayev T, **Franklin MJ**, Baer DG, Hamblin MR, “Photodynamic therapy for *Acinetobacter baumannii* burn infections in mice,” *Antimicrob Agents Chemother*, 2009; 53:3929–3934. Abstract 09-037

Elias DA, Drury EC, Redding AM, Mukhopadhyay A, Yen H-CB, **Fields MW**, Hazen TC, Arkin AP, Keasling JD, and Wall JD, “Expression profiling of hypothetical genes in *Desulfovibrio vulgaris* leads to improved functional annotation,” *Nucleic Acids Res*, 2009; 37:2926–2939. Abstract 09-044

**Faulwetter JL**, Gagnon V, Sundberg C, Chazarenc F, **Burr MD**, Brisson J, Tonderski K, **Camper AK** and **Stein OR**, “Microbial processes influencing performance of treatment wetlands: A review,” *Ecological Eng*, 2009; 35(6):987–1004. Abstract 09-038

**Goeres D**, “Understanding the importance of biofilm growth in hot tubs,” In: *Applied biomedical microbiology: A biofilms approach*. DS Paulson, (ed) 2009; pp. 59–79; CRC Press. Abstract 09-030

**Hamilton M, Buckingham-Meyer K, and Goeres DM**, “Checking the validity of the harvesting and disaggregating steps in laboratory tests of surface disinfectants,” *J AOAC International*, 2009; 92(6):1755–1762. Abstract 09-032

Holman HYN, Wozeia E, Lin Z, Comolli LR, Ball DA, Borglin S, **Fields MW**, Hazen TC, Downing KH, “Real-time molecular monitoring of chemical environment in obligate anaerobes during oxygen adaptive response,” *Proc Natl Acad Sci, USA*, 2009; 106(31):12599–12604. Abstract 09-045

**Jennings LK**, Chartrand MMG, Lacrampe-Couloume G, Sherwood Lollar B, Spain JC, Gossett JM, “Proteomic and transcriptomic analyses reveal genes upregulated by cis-dichloroethene in *Polaromonas* sp. strain JS666,” *Appl Environ Microbiol*, 2009; 75(11):3733–3744. Abstract 09-022

**Khan MMT, Lewandowski Z**, Takizawa S, Yamada K, Katayama H, Yamamoto K, Ohgaki S, “Continuous and efficient removal of THMs from river water using MF membrane combined with high dose of PAC,” *Desalination*, 2009; 249:713–720. Abstract 09-034

**Kirker KR, Fisher ST, James GA**, McGhee D, Shah CB, “Efficacy of polyhexamethylene biguanide-containing antimicrobial foam dressing against MRSA relative to standard foam dressing,” *Wounds*, 2009; 21(9):229–233. Abstract 09-028

**Kirker KR, Secor PR, James GA**, Fleckman P, Olerud JE, **Stewart PS**, “Loss of viability and induction of apoptosis in human keratinocytes exposed to *Staphylococcus aureus* biofilms in vitro,” *Wound Repair Regen*, 2009; 17(5):690–699. Abstract 09-026

**Klayman BJ, Volden PA, Stewart PS, Camper AK**, “*Escherichia coli* O157:H7 requires colonizing partner to adhere and persist in a capillary flow cell,” *Environ Sci Technol*, 2009; 43(6):2105–2111. Abstract 09-013

**Lennox J, Ashe J**, “Biofilms and biobarriers,” *The American Biology Teacher*, 2009; 71(1):20–26. Abstract 09-025

**Lewandowski Z**, Beyenal H, “Methods for imaging and quantifying the structure of biofilms in food processing and other environments,” In: *Biofilms in the food and beverage industries*. PM Fratamico, BA Annous and NW Gunther IV (eds). CRC Press 2009. pp. 99–130. Abstract 09-031

**Moberly JG, Borch T**, Sani RK, Spycher NF, Sengor SS, Ginn TR, **Peyton BM**, “Heavy metal-mineral associations in Coeur d'Alene River sediments: A synchrotron-based analysis,” *Wat, Air, Soil Poll*, 2009; 201(1-4):195–208. Abstract 09-041

## 2010 Publications

Nivens DE, Co B, and **Franklin MJ**, "Sampling and quantification of biofilms in food processing and other environments," In: *Biofilms in the Food and Beverage Industries*. (Fratamico, Annous, and Gunther eds.) Woodland Publishing Ltd. 2009. Abstract 09-042

**Pulcini E, James G**, "Biofilms and device implants," In: (Editor) *Applied biomedical microbiology: A biofilms approach*. DS Paulson, (ed) 2009; pp. 59–79 CRC Press. Abstract 09-029

Rastogi G, Sani RK, **Peyton BM, Moberly JG**, Ginn TR, "Molecular studies on the microbial diversity associated with mining-impacted Coeur d'Alene river sediments," *Microb Ecol*, 2009; 58(1):129–139. Abstract 09-040

Rastogi G, Stetler LD, **Peyton BM**, and Sani RK, "Molecular analysis of prokaryotic diversity in the deep subsurface of the former Homestake Gold Mine, South Dakota, USA," *J Microbiol*, 2009; 47(4):371–384. Abstract 09-043

**Stewart PS, Davison WM**, Steenbergen JN, "Daptomycin rapidly penetrates a *Staphylococcus epidermidis* biofilm," *Antimicrob Agents Chemother*, 2009; 53:3505–3507. Abstract 09-023

**Taffs R, Aston JE, Brileya K**, Jay Z, Klatt CG, McGlynn S, **Mallette N**, Montross S, **Gerlach R**, Inskeep WP, Ward DM, **Carlson RP**, "In silico approaches to study mass and energy flows in microbial consortia: A syntrophic case study," *BMC Systems Biology*, 2009, 3:114. Abstract 09-033

Tomasino SF, Pines RM, **Hamilton MA**, "Improving the AOAC use-dilution method by establishing a minimum log density value for test microbes on inoculated carriers," *J AOAC International*, 2009; 92(5):1531–1540. Abstract 09-027

Yeon K-M, Cheong W-S, Oh H-S, Lee W-N, Hwang B-K, Lee C-H, Beyenal H, **Lewandowski Z**, "Quorum sensing: A new biofouling control paradigm in a membrane bioreactor for advanced wastewater treatment," *Environ Sci Technol*, 2009; 43:380–385. Abstract 09-035

Zhang P, **Leach LH, Camper AK**, Goslan EH, Parson SA, Xie YF, Hozalski RM, and LaPara TM, "Isolation and characterization of novel haloacetic acid-degrading bacteria from drinking water," *FEMS Microbiol Lett*, 2009; 297(2):203–208. Abstract 09-039

**Ammons MCB**, "Anti-biofilm strategies and the need for innovations in wound care," *Recent Pat Anti-infect Drug Discov*, 2010; 5(1):10–17. Abstract 10-002

**Field EK, D'Imperio S**, Miller AR, **VanEngelen MR, Gerlach R**, Lee BD, Apel WA, **Peyton BM**, "Application of molecular techniques to elucidate the influence of cellulosic waste on the bacterial community structure at a simulated low level waste site," *Appl Environ Microbiol*, 2010; 76(10):3106–3115. Abstract 10-006

**Foreman CM** et al, National Academy of Science Panel, "Revitalizing NASA's suborbital program: Advancing science, driving innovation, and developing workforce." Released to Congress and NASA, 16 February 2010, 87pp.

He Q, He Z, Joyner DC, Joachimiak M, Price MN, Yang ZK, Yen H-C B, Hemme CL, Chen W, **Fields MW**, Stahl DA, Keasling JD, Keller M, Arkin AP, Hazen TC, Wall JD, Zhou J, "Impact of elevated nitrate on sulfate-reducing bacteria: A comparative study of *Desulfovibrio vulgaris*," *Nature ISME J*, 2010; epublished May 6. Abstract 2010-016

He Z, Zhou A, Baidoo E, He Q, Joachimiak MP, Benke P, Phan R, Mukhopadhyay A, Hemme CL, Huang K, Alm EJ, **Fields MW**, Wall JD, Stahl DA, Hazen TC, Keasling JD, Arkin AP, and Zhou J, "Global transcriptional, physiological, and metabolite analyses of the responses of *Desulfovibrio vulgaris* Hildenborough to salt adaptation," *Appl Environ Microbiol*, 2010; 76:1574–1586. Abstract 10-014

Hemme CL, Deng Y, Gentry TJ, **Fields MW**, Wu L, **Barua S**, Barry K, Tringe SG, Watson DB, He Z, Hazen TC, Tiedje JM, Rubin EM, and Zhou J, "Metagenomic insights into evolution of a heavy metal-contaminated groundwater microbial community," *Nature ISME J*, 2010; 4:660–672. Abstract 10-015

Khan MMT, **Stewart PS**, Moll DJ, Mickols WE, **Burr MD, Nelson SE, Camper AK**, "Assessing biofouling on polyamide reverse osmosis (RO) membrane surfaces in a laboratory system," *J Membrane Sci*, 2010; 349(1-2):429–437. Abstract 10-008

McGlynn SE, Boyd ES, Shepard EM, Lange R, **Gerlach R**, Broderick JB, Peters JW, "Identification and characterization of a novel member of the radical AdoMet enzyme superfamily and implications for the biosynthesis of the Hmd hydrogenase active site cofactor," *J Bacteriol*, 2010; 192(2):595–598. Abstract 2010-017



**McLeod BR, Sandvik EL**, "A biofilm growth protocol and the design of a magnetic field exposure setup to be used in the study of magnetic fields as a means of controlling bacterial biofilms," *Bioelectromagnetics*, 2010; 31(1):56–63. Abstract 10-001

**Parker A**, Dimitrov A, and Gedeon T, "Symmetry breaking clusters in soft clustering decoding of neural codes," *IEEE Transactions on Information Theory: Special Issue on Molecular Biology and Neuroscience*, 2010; 56(2):901–927. Abstract 10-004

**Pérez-Osorio AC, Williamson KS, Franklin MJ**, "Heterogeneous rpoS and rhlR mRNA levels and 16S rRNA/rDNA ratios within *Pseudomonas aeruginosa* biofilms, sampled by laser capture microdissection," *J Bacteriol.* 2010; 192(12):2991–3000. Abstract 10-007

Rickard AH, Colacino KR, Manton KM, Morton RI, **Pulcini E**, Pfeil J, Rhoads D, Wolcott RD, **James G**, "Production of cell-cell signaling molecules by bacteria isolated from human chronic wounds," *J Appl Microbiol*, 2010; 108(5):1509–1522. Abstract 10-012

Sani RK, Rastogi G, **Moberly JG**, Dohnalkova A, Ginn TR, Spycher N, Shende RV, **Peyton, BM**, "The toxicity of lead to *Desulfovibrio desulfuricans* G20 in the presence of goethite and quartz," *J Basic Microbiology*, 2010; 50:160–170. Abstract 10-009

Stephenson MF, Mfunu L, Dowd SE, Wolcott RD, Barbeau J, Poisson M, **James G**, Desrosiers M, "Molecular characterization of the polymicrobial flora in chronic rhinosinusitis," *J Otolaryngol Head Neck Surg*, 2010; 39(2):182–187. Abstract 10-013

Tomasino SF, **Hamilton MA**, Pines RM, "Use of alternative carrier materials in AOAC official method SM 2008.05, efficacy of liquid sporicides against spores of *Bacillus subtilis* on a hard, nonporous surface, quantitative three-step method," *J AOAC International*, 2010; 93(1):259–276. Abstract 10-003

**VanEngelen MR, Field EK, Gerlach R**, Lee BD, Apel WA, **Peyton BM**, "UO<sub>2</sub><sup>+2</sup> Speciation determines uranium toxicity and bioaccumulation in an environmental *Pseudomonas sp.* isolate," *Environ Toxicol Chem*, 2010; 29(4):763–769. Abstract 10-010

Wezensky SJ, Hanks TS, Wilkison MJ, **Ammons MC**, Siemsen DW, Gauss KA, "Modulation of PLAGL2 transactivation by positive cofactor 2 (PC2), a component of the ARC/Mediator complex," *Gene*, 2010; 452(1):22–34. Abstract 10-011

**Ziganshin AM, Gerlach R**, Naumenko EA, Naumova RP, "Aerobic degradation of 2,4,6-trinitrotoluene by the yeast strain *Geotrichum candidum* AN-Z4," *Microbiology*, 2010; 79(2):178–183. Abstract 10-018

**Ziganshin AM**, Naumova RP, **Pannier AJ, Gerlach R**, "Influence of pH on 2,4,6-trinitrotoluene degradation by *Yarrowia lipolytica*," *Chemosphere*, 2010; 79(4):426–433. Abstract 10-005

RESEARCH:  
 PRESENTATIONS  
 June 2009–May 2010

**Ross Carlson** presented a bioinformatics workshop at Idaho National Laboratory, Idaho Falls, ID, June 1–4, 2009.

**Paul Sturman** and **Anne Camper** presented “Biofilms in industrial processes” to The Sherwin-Williams Company, Cleveland, OH, June 3, 2009.

**Phil Stewart** as invited speaker presented “Biofilms in chronic wounds” at the Gordon Research Conference, Colby-Sawyer College, New London, NH, June 15–18, 2009.

**Bruce McLeod** as invited speaker presented “Engineering new approaches to clearing biofilm infections,” BioEM 2009, Davos, Switzerland, June 15–19, 2009.

Graduate student **Lisa Kirk** presented “Geomicrobiological control of selenium solubility in subsurface phosphate overburden deposits,” Goldschmidt Geochemistry Conference, Davos, Switzerland, June 21–26, 2009. In: Goldschmidt Abstracts – K, Abstract A661, *Geochimica et Cosmochimica Acta*, Vol.73, No.13, Supplement: June, 2009. Co-authors: Childers SE, **Peyton B**, McDermott T, **Gerlach R**, Johnson TM.

**Al Cunningham** presented, “Environmental responses to carbon mitigation through geological storage,” DOE EPSCoR Annual Meeting, Brookhaven National Lab, Long Island, NY, July 20–23, 2009.

Graduate student **Logan Schultz** presented “Imaging biomineralization in flow systems” at the Microscopy and Microanalysis Conference, Richmond, VA, July 25–31, 2009.

**Zbigniew Lewandowski** presented “Microbial fuel cells to power submersed electronic devices,” ACS National Meeting & Exposition, Washington, DC, August 16–20, 2009.

Graduate student **Crystal Richards** presented the poster “Detection of opportunistic pathogens and associated biofilms in rural Montana,” Eurobiofilms 2009 Meeting, Rome, Italy, September 1–6, 2009.

**Phil Stewart** as invited speaker presented “Physiological heterogeneity of bacteria in biofilms,” Eurobiofilms 2009 Meeting, Rome, Italy, September 1–6, 2009.

**Phil Stewart** visited Bausch & Lomb and presented “Biofilm infections and issues in biofilm control,” Rochester, NY, September 9–12, 2009.

**Marty Hamilton** presented an overview of proposed guidelines for the “Statistical analysis of collaborative studies to evaluate attributes of disinfectant test methods,” AOAC International Annual Meeting, Philadelphia, PA, September 12–15, 2009. The creation of the proposed guidelines was supported by the EPA under a contract with the Standardized Biofilm Methods Laboratory.

The following presentations were made to GOJO Industries, Inc., Akron, OH, September 14, 2009:

**Matthew Fields** presented “Physiology and ecology of environmental biofilms.”

**Darla Goeres** presented “Biofilm: Dynamic cooperative communities of bacteria and CBE researchers.”

**Lindsey Lorenz** presented “Contaminated bulk soap dispensers: Comparison of two methods of analysis and washing study methods and results.”

**Brad Ramsay** presented “Analysis of microbial communities: Knock, knock. Who’s there?”

**Isaac Klapper** presented “Physical-chemical based modeling of biofilm induced mineralization,” IWA Biofilm Conference, Davis, CA, September 14, 2009. Co-author: **Zhang T**.

**Zbigniew Lewandowski** gave the plenary presentation “From microbial corrosion to microbial fuel cells,” IWA Biofilm Conference, Davis, CA, September 14, 2009.

Haluk Beyenal presented “Reconstructing biofilm structure from calculated parameters,” IWA Biofilm Conference, Davis, CA, September 15, 2009. Co-authors: Renslow R, **Lewandowski Z**.

Graduate student **Mari Eggers** and Crescentia Cummins co-presented “Developing community-based participatory research with Little Big Horn College, the Crow Reservation Community and Montana State University” at the Western Region COBRE-INBRE Scientific Conference, Big Sky, Montana, September 16–18, 2009. They also presented the poster “Community based risk assessment on the Crow Reservation.”

Graduate student **Mari Eggers** co-facilitated a session on Community Based Participatory Research at the STAR/GRO EPA Fellows Conference, Washington, DC, September 20–23, 2009. She also presented the poster “Community based risk assessment on the Crow Reservation.”

Graduate student **Crystal Richards** presented the poster "Pathogen detection in source and drinking water: A community based approach to exposure assessment on the Crow Reservation," STAR/GRO EPA Fellows Conference, Washington, DC, September 20–23, 2009.

Graduate student **Andrew Meehan** presented "Energy harvest with microbial fuel cell and power management system," at the Institute of Electrical and Electronics Engineers (IEEE) Energy Conversion Congress, in San Jose, California, September 20–24, 2009. Co-authors: Gao H and **Lewandowski Z**.

**Bruce McLeod** as invited speaker presented "A review of biofilms and new approaches for clearing biofilm infections," Special Presentation for the Pre-med, Biology, Chemistry, Nursing, Physical Therapy and Honors College, faculty and students, West Chester University, West Chester, PA, September 23, 2009.

**Otto Stein** presented at the Third International Conference on Wetland Systems for Water Pollution Control (WETPOL), Barcelona, Spain, September 20–24, 2009:

**Keynote presentation:** "Patterns of rootzone oxidation in treatment wetland microcosms across diverse plant species." Co-authors: Hook PB, **Taylor CR**, Zabinski CA.

**Presentation:** "Identification of microbial functional groups within a sub-surface treatment wetland as influenced by plant species selection and season." Co-authors: **Faulwetter JL**, **Burr MD**, **Camper AK**.

**Phil Stewart** presented "Physiology of microbial biofilm," University of Notre Dame, South Bend, IN, September 29–30, 2009.

Graduate student **Luis Serrano-Figueroa** presented the poster "Extraction, characterization and purification of bacterial siderophores," at the 2009 Society for the Advancement of Chicanos, Latinos and Native Americans in Science (SACNAS) Conference, in Dallas, TX, October 2009. Authors: **Serrano-Figueroa LO** and **Richards A**.

**Paul Sturman** presented "Biofilms in industrial water systems," Parenteral Drug Association Global Conference on Pharmaceutical Microbiology, Bethesda, MD, October 5–7, 2009.

**Paul Sturman** presented "Current perspectives in biofilm growth," Parenteral Drug Association Global Conference on Pharmaceutical Microbiology, Bethesda, MD, October 6, 2009.

**Anne Camper** presented "Biofilms and emerging pathogens," Water Environment Federation Technical Exhibition and Conference (WEFTEC) workshop on Reclaimed Water Facilities: Meeting Existing and Emerging Challenges, Orlando, FL, October 11, 2009.

**Al Parker** presented "Using linear solvers to sample large Gaussians" at the Department of Mathematical Sciences Colloquium at the University of Montana, Missoula, October 19, 2009.

**Paul Sturman** and **Garth James** presented "Biofilms in industry and medicine," to companies Bayer (Pittsburgh, PA), Johnson & Johnson (Skillman, NJ), and Becton Dickinson, (Franklin Lakes, NJ), October 19–21, 2009.

**Darla Goeres** visited the CDC and presented "Progress in biofilm standardized methods: Development and validation of a treatment method," Atlanta, GA, October 21, 2009. Darla also attended ASTM E35.15 subcommittee meeting, Atlanta, GA, October 21–23, 2009.

**Diane Walker** presented "Statistical analysis of experimental data from the MBEC method," ASTM E35 Committee Meeting, Atlanta, GA, October 22, 2009.

**Phil Stewart** presented "Antimicrobials vs. biofilms" and "Biofilm methods update," to BASF, Boston, MA, and Harvard University, Boston, MA, October 27, 2009.

Undergraduate **Trevor Zuroff** presented the poster "Counterintuitive effects of quorum sensing on biofilm antibiotic tolerance," 2009 AIChE Student Conference and the 2009 AIChE Professional Conference, Nashville, TN, November 6–13, 2009. Co-authors: **Lloyd-Randolph J**, **Jimenez L**, **Bernstein H**, **Carlson RP**.

**Ross Carlson** attended 2009 AIChE (American Institute of Chemical Engineers) Annual Meeting, Nashville, TN, November 9–13, 2009 and presented the following three papers:

"Decomposing complex microbial behaviors using cost-benefit analysis."

"Molecular level *in silico* analysis of mass and energy flows in microbial communities." Co-author: **Taffs R**.

"Counterintuitive effects of quorum sensing on biofilm antibiotic tolerance." Co-author: **Zuroff T**.

**David Miller** presented "The effect of treatments on the mechanical properties of biofilms," Proceedings of the 2009 International Mechanical Engineering Conference and Exposition, Lake Buena, FL., November 15–20, 2009. Co-authors: **Stewart PS**, **Brindle E**.

The following MSU speaker presentations were made at the **5th ASM Conference on Biofilms**, Cancun, Mexico, November 15–19, 2009:

**Anne Camper** presented “Nitrification in drinking water systems.”

**Mike Franklin** presented “Use of laser capture microdissection microscopy and quantitative RT-PCR to characterize localized gene expression in biofilms.”

**Phil Stewart** presented “Altering biofilm cohesion as a control strategy.”

**Dave Ward** presented “Composition, structure and function of hot spring cyanobacterial mat communities.”

The following poster presentations were made at the 5th ASM Conference on Biofilms, Cancun, Mexico, November 15–19, 2009:

**Alessandra Agostinho** presented “An in vitro model for the growth and analysis of chronic wound MRSA biofilms.” Co-author: **James GA**.

**Sarah Codd** presented “Magnetic resonance approaches to investigate the correlation between biological function and transport phenomena in biofilms.” Co-authors: **Hornemann JA, Seymour JD**.

**Robin Gerlach** presented “Utility of biofilms in geological carbon sequestration.” Co-authors: **Cunningham AB, Mitchell AC**.

**Lindsey Lorenz** presented “Evaluation of contaminated bulk soap dispensers for biofilm bacteria: Comparison of two methods of analysis and effectiveness of dispenser washing procedures.”

**Betsey Pitts** presented “Visualizing the biofilm matrix using new and classic fluorescent stains.” Co-author: Diane Gray, Life Technologies, Molecular Probes.

**Phil Stewart** presented “Physiological activities and growth rate of *Pseudomonas aeruginosa* in biofilms revealed by transcriptional profiling.” Co-author: **Folsom JP**.

Graduate student **Pat Secor** presented “The impacts of *S. aureus* biofilm on primary human keratinocytes.” Co-authors: **Kirker K, James G, Fleckman P, Olerud J, Stewart P**.

**Paul Sturman** presented two posters: “Industrially relevant research” and “CBE methods development, testing, and workshops.”

**CBE faculty and staff** conducted a workshop “Standardized biofilms methods—grow, treat, sample, and analyze: Standardizing biofilm methods for routine use,” 5<sup>th</sup> ASM Conference on Biofilms, Cancun, Mexico,

November 15–19, 2009. CBE instructors included **Darla Goeres, Diane Walker, Lindsey Lorenz, and Al Parker**. Additional instructors were Nick Allan and Merle Olsen, of Innovotech.

Crescentia Cummins (Little Big Horn College), Tim Ford (University of New England), **Mari Eggers**, and three members of the Crow Environmental Health Steering Committee gave a Webinar for the EPA: “Community based risk assessment of exposure to contaminants via water sources on the Crow Reservation in Montana,” as part of the EPA series Promoting Environmental Health in Native American Communities, November 18, 2009, Washington, D.C.

**Darla Goeres** presented “Standardized methods: Development and validation of a treatment method” and **Al Parker** presented “Ruggedness assessment and experimental design in the biofilm laboratory,” to representatives of the Biological and Economic Analysis Division (BEAD) and Antimicrobials Division (AD) of the EPA, Fort Meade, Maryland, December 2–3, 2009.

**Al Cunningham** presented “Utility of biofilms in geologic carbon sequestration,” AGU Meeting, San Francisco, CA, December 13–16. Co-authors: **Gerlach R, Mitchell A**.

**Paul Sturman** presented, “Biofilm growth and control in industrial water systems,” Genentech, San Francisco, CA, January 11, 2010.

**Isaac Klapper** presented “Importance of layering in ecology and function of microbial biofilms,” at the Dynamics of Layering in Biological Systems Conference, Pasadena, CA, January 14–18, 2010.

Graduate student **Natasha Mallette** presented “EFRI-HyBi: Fungal processes for direct bioconversion of cellulose to hydrocarbons,” at the EFRI Annual Meeting, Arlington, Virginia, March 2010. Co-authors: **Peyton BM, Carlson RP**.

**Zbigniew Lewandowski** presented “Biofilms on electrically conductive surfaces,” at the College of Environmental Science and Engineering, Tongji University, Shanghai, China. He also attended the International Water Association Meeting, Beijing, China, March 10–22, 2010.

**Matthew Fields** was invited to present the plenary talk at the Missouri ASM branch meeting in Springfield, MO, April 15–17, 2010. The title of his talk was “Triglyceride accumulation in microalgae and extremophilic microalgae for lipid-derived biofuels.”

**Phil Stewart, Garth James** and **Paul Sturman** presented a seminar: "Biofilms in medicine" at the FDA, Silver Spring, MD, April 6, 2010.

**Phil Stewart** presented "Biofilms as agents of persistent infection."

**Garth James** presented "Biofilms in medicine and dentistry."

**Paul Sturman** presented "Biofilm growth models and standardization."

**Phil Stewart**, as an invited speaker, presented "Fundamental and applied aspects of biofilm control and removal," International Membrane Biofouling Symposium, Bisbee, AZ, April 29, 2010.

**Robin Gerlach** presented the poster "Bacterially induced calcite precipitation and strontium co-precipitation under flow conditions in a porous media system," EGU General Assembly 2010, Vienna, Austria, May 2–7, 2010. Co-authors: **Gerlach R, Mitchell AC, Schultz LN, Cunningham AB**.

**Robin Gerlach** presented "Biologically enhanced geologic carbon sequestration," EGU General Assembly 2010, Vienna, Austria, May 2–7, 2010. Co-authors: **Mitchell AC, Spangler LH, Cunningham AB**.

**Robin Gerlach** as invited speaker presented "Role of biofilms in geological carbon sequestration," EGU General Assembly 2010, Vienna, Austria, May 2–7, 2010. Co-authors: **Mitchell AC, Spangler LH, Cunningham AB**.

**Al Cunningham** presented a poster "Microbially enhanced solubility and mineral trapping of sequestered supercritical CO<sub>2</sub>," at the 9th Annual Carbon Capture & Sequestration Conference, Pittsburg, PA, May 10–13, 2010.

**Joe Seymour** as invited speaker presented "MR measurements and non-equilibrium statistical mechanics models of bioreactive systems and colloid transport" at Stanford University, Palo Alto, CA, May 12, 2010.

**Phil Stewart** presented "Physiological activities and growth rate of *Pseudomonas aeruginosa* in biofilms revealed by transcriptional profiling," American Society for Microbiology Meeting, San Diego, CA, May 26, 2010.

## EDUCATION:

Graduate Students: Summer 2009, Fall 2009, Spring 2010

\*Graduating

**Masters Candidates**

1. Akabari, Ratilal (Z Lewandowski)	M	Microbiology	India
2. Barnhart, Elliott (Fields/Cunningham)	M	Microbiology	Broadus, MT
3. Brindle, Eric* (P Stewart)	M	Mech & Ind Eng	Bozeman, MT
4. Bugni, Steven (R Gerlach)	M	Civil Eng	E. Helena, MT
5. Elm, Margaret (G James)	F	Health Sciences	Woodinville, WA
6. Eustance, Everett (B Peyton)	M	Chem & Bio Eng	Great Falls, MT
7. Girardot, Crystal (B Peyton)	F	Chem & Bio Eng	Billings, MT
8. Moll, Karen (B Peyton)	F	Chem & Bio Eng	Fairport, NY
9. Mousseau, Kenneth* (A Richards)	M	Chem & Bio Eng	Ontario, Canada
10. Schultz, Logan* (A Cunningham)	M	Chem & Bio Eng	Chelan, WA
11. Smith, Heidi (C Foreman)	F	LRES	Westford, VT

**PhD Candidates**

1. Aston, John* (B Peyton)	M	Chem & Bio Eng	Bozeman, MT
2. Behnke, Sabrina (A Camper)	F	Microbiology	Voerde, Germany
3. Bernstein, Hans (R Carlson)	M	Chem & Bio Eng	Kalispell, MT
4. Brileya, Kristen (M Fields)	F	Microbiology	Bozeman, MT
5. De León, Kara (M Fields)	F	Microbiology	Bozeman, MT
6. Dieser, Markus* (C Foreman)	M	Land Res & Env Sci	Walchsee, Austria
7. Eggers, Margaret (A Camper)	F	Microbiology	California
8. Encarnacion, Gem (A Camper)	F	Microbiology	The Philippines
9. Faulwetter, Jennifer (A Camper)	F	Microbiology	Morgan Hill, CA
10. Field, Erin (R Gerlach)	F	Microbiology	Deep River, CT
11. Gardner, Robert (B Peyton)	M	Chem & Bio Eng	Afton, WY
12. Hornemann, Jennifer* (S Codd)	F	Chem & Bio Eng	Bozeman, MT
13. Hunt, Kristopher (R Carlson)	M	Chem & Bio Eng	Thorp, WI
14. Kirk, Lisa (B Peyton)	F	Chem & Bio Eng	Bozeman, MT
15. Mallette, Natasha (P Stewart)	F	Chem & Bio Eng	Fayetteville, AR
16. Mitchell, Angela (G James)	F	Molecular Biosci	Butte, MT
17. Moberly, James* (B Peyton)	M	Chem & Bio Eng	Moscow, ID
18. O'Shea, Kelly (M Fields)	F	Microbiology	Colorado Springs, CO
19. Plaggemeyer, Sara (A Camper)	F	Microbiology	Big Timber, MT
20. Richards, Crystal (A Camper)	F	Microbiology	Bozeman, MT
21. Sandvik, Elizabeth (B McLeod)	F	Chem & Bio Eng	Rapid City, SD
22. Secor, Pat (E Pulcini)	M	Cell Bio & Neurosci	Bozeman, MT
23. Serrano Figueroa, Luis (A Richards)	M	Microbiology	Puerto Rico
24. Severson, Grant (G James)	M	Microbiology	Claremore, OK
25. Sundararajan, Anitha (M Fields)	F	Microbiology	India
26. Taffs, Reed (R. Carlson)	M	Civil Engineering	Helena, MT
27. Tigges, Michelle (M Fields )	F	Molecular Biosci	Battle Lake, MN
28. Valenzuela, Jacob (M Fields)	M	Biochemistry	San Luis Obispo, CA
29. Van Engelen, Catherine* (B Peyton)	F	Chem & Bio Eng	Lake City, PA
30. Van Engelen, Michael* (B Peyton)	M	Chem & Bio Eng	Spokane, WA
31. VanKempen-Fryling, Rachel (A Camper)	F	Molecular Biosci	Grand Rapids, MI
32. Vogt, Sarah (J Seymour)	F	Chem & Bio Eng	Rolla, MO
33. Waters, Ryan (R Gerlach)	M	Math	Hot Springs, AR

Graduate Students, 2009–2010

1: Biochemistry

**PhD:** Valenzuela, Jacob (PhD, M Fields)  
 1 M

1: Cell Biology & Neuroscience

**PhD:** Secor, Pat (PhD, E Pulcini)  
 1 M

17: Chemical & Biological Engineering

**MS: 5**

3 M Eustance, Everett (MS, B Peyton)  
 2 F Girardot, Crystal (MS, B Peyton)  
 Mousseau, Kenneth (MS, A Richards)  
 Moll, Karen (MS, B Peyton)  
 Schultz, Logan (MS, A Cunningham)

**PhD: 12** Aston, John (PhD, B Peyton)

6 M Bernstein, Hans (PhD, R Carlson)  
 6 F Gardner, Robert (PhD, B Peyton)  
 Hornemann, Jennifer (PhD, S Codd)  
 Hunt, Kristopher (PhD, R Carlson)  
 Kirk, Lisa (PhD, B Peyton)  
 Mallette, Natasha (PhD, R Gerlach)  
 Moberly, James (PhD, B Peyton)  
 Sandvik, Elizabeth (PhD, B McLeod)  
 VanEngelen, Catherine (PhD, B Peyton)  
 VanEngelen, Michael (PhD, B Peyton)  
 Vogt, Sara (PhD, J Seymour)

2: Civil / Environmental Engineering

**MS:** Bugni, Steven (MS, R Gerlach)  
 1 M  
**PhD:** Taffs, Reed (PhD, R Carlson)  
 1 M

1: Health Services

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

2: Land Resources & Environmental Sciences

**MS:** Smith, Heidi (MS, C Foreman)  
 1 F  
**PhD:** Dieser, Markus (PhD, C Foreman)  
 1 M

1: Math

**PhD:** Waters, Ryan (PhD, R Gerlach)  
 1 M

1: Mechanical & Industrial Engineering

**MS:** Brindle, Eric (MS, P Stewart)  
 1 M

16: Microbiology

**MS: 2** Akabari, Ratilal (MS, Z Lewandowski)  
 2 M Barnhart, Elliott (MS, Fields/Cunningham)

**PhD: 13** Behnke, Sabrina (PhD, A Camper)

2 M Brileya, Kristen (PhD, M Fields)  
 11 F De Leon, Kara (PhD, M Fields)  
 Eggers, Margaret (PhD, A Camper)  
 Encarnacion, Gem (PhD, A Camper)  
 Faulwetter, Jennifer (PhD, M Burr)  
 Field, Erin (PhD, R Gerlach)  
 O'Shea, Kelly (PhD, M Fields)  
 Plaggemeyer, Sara (PhD, A Camper)  
 Richards, Crystal (PhD, A Camper)  
 Serrano Figueroa, Luis (PhD, A Richards)  
 Severson, Grant (PhD, G James)  
 Sundararajan, Anitha (PhD, M Fields)

**Rotations and Traineeships**

3: Molecular Bioscience

**PhD** Mitchell, Angela (PhD, G James)  
 3 F Tigges, Michelle (PhD, M Fields)  
 VanKempen-Fryling, Rachel (PhD, A Camper)

**TOTALS**

**Total Grads: 44**

Total MS: 11 7 M / 4 F  
 Total PhD: 33 13 M / 20 F  
 Total Male: 20  
 Total Female: 24





**EDUCATION:**

Undergraduate Students: Summer 2009, Fall 2009, Spring 2010

**Undergrads: Summer 2009, Fall 2009, Spring 2010**

1. Adam, Salman (D Walker)	M	Mechanical Engineering Technology	Pakistan
2. Anderson, Steven (D Walker)	M	Mechanical Engineering Technology	Gardiner, MT
3. Bader, Erica (A Richards)	F	Chemical & Biological Engineering	Boulder, CO
4. Blaskovich, John (R Gerlach)	M	Chemical & Biological Engineering	Butte, MT
5. Bozeman, Jared (B Peyton)	M	Cell Biology & Neuroscience	Bozeman, MT
6. Butz, Thomas (E Pulcini)	M	Chemical & Biological Engineering	Bozeman, MT
7. DeGroat, Alec (M Fields)	M	Microbiology	Billings, MT
8. Downey, Carey (M Fields)	F	Microbiology	Pocatello, ID
9. Durgan, Chris (P Sturman)	M	Chemical & Biological Engineering	Spokane, WA
10. Fabich, Hilary (S Codd)	F	Chemical & Biological Engineering	Livingston, MT
11. Gardner, Phillip (M Fields)	M	Cell Biology & Neuroscience	Bozeman, MT
12. Gittins, Tyler (R Gerlach)	M	Chemical & Biological Engineering	Lawrence, KS
13. Gulick, Stesha (B Peyton)	F	Chemical & Biological Engineering	Helena, MT
14. Harrer, Travis (A Richards)	M	Chemical & Biological Engineering	Great Falls, MT
15. Hoops, Jeanette (E Pulcini)	F	Nursing (Bridges)	Bozeman, MT
16. Justin, Grant (M Fields)	M	Microbiology	Bozeman, MT
17. Kennedy, Collette (B Peyton)	F	Chemical & Biological Engineering	Fairbanks, AK
18. Lawlor, Collins (B Peyton)	M	Chemical & Biological Engineering	Helena, MT
19. McNelis, Kiera (R Carlson)	F	Chemical & Biological Engineering	Belgrade, MT
20. Mean, Maxwell (G James)	M	Cell Biology & Neuroscience	Liberty Lake, WA
21. Oksness, Garret (E Pulcini)	M	Microbiology	Bozeman, MT
22. Pankratz, Elle (B Peyton)	F	Mechanical & Industrial Engineering	Clancy, MT
23. Perkins, Myles (D Goeres)	M	Chemical & Biological Engineering	Albuquerque, NM
24. Popovitch, Paul (A Richards)	M	Chemical & Biological Engineering	Kalispell, MT
25. Purdy, Kim (A Richards)	F	Chemical & Biological Engineering	Buffalo, WY
26. Rich, Zach (C Foreman)	M	Land Resources & Environmental Sci	Bozeman, MT
27. Schonenbach, Nicole (B Peyton)	F	Chemical & Biological Engineering	Ashland, MT
28. Staven, Ari (B Peyton)	F	Chemical & Biological Engineering	Georgetown, TX
29. Tate, Patrick (R Carlson)	M	Chemical & Biological Engineering	Vancouver, WA
30. Thiel, Joseph (P Stewart)	M	Chemical & Biological Engineering	Idaho Falls, ID
31. Garret Vo (Heys)	M	Mathematics and Physics	
32. Young, Mary Lynn (M Fields)	F	Biochemistry	Boise, ID
33. Zhang, Pei (R Carlson)	M	Chemical & Biological Engineering	China
34. Zuroff, Trevor (R Carlson)	M	Chemical & Biological Engineering	Bozeman, MT

**Undergraduates Summary: 2009-2010**

<b>Discipline / Program</b>	<b>Male</b>	<b>Female</b>	<b>Total</b>
Biochemistry		1	1
Cell Biology & Neurosci	3		3
Chem & Bio Eng	12	8	20
Environmental Sci (LRES)	1		1
Mech & Industrial Eng		1	1
Mech Eng Technology	2		2
Microbiology	3	1	4
Nursing (Bridges)		1	1
Physics	1		1
<b>Totals</b>	<b>22</b>	<b>12</b>	<b>34</b>

**EDUCATION:**

2010 MSU Student Research  
 Celebration: CBE Participants

Montana State University graduate and undergraduate students who conducted research this school year presented their findings April 8, 2009, at the Student Research Celebration in the Strand Union Building at MSU, Bozeman. Fifteen students working on CBE projects participated in the event by preparing and presenting research posters. Event sponsors were Montana EPSCoR Program, Montana INBRE Program, and the Montana Space Grant Consortium. The Undergraduate Scholars Program, Office of the Provost and Office of Graduate Education organized this year's celebration.

Poster presentations by students mentored by CBE researchers are listed below.

**Student Presenters:**

***Salman Adam*** and ***Steven Anderson***

Undergraduates, Mechanical & Engineering  
 Technology

**Poster Title:** Biofilm efficacy test

**CBE Faculty Mentor:** Kevin Cook, Mechanical &  
 Engineering Technology

**Student Presenter:**

***Elliott Barnhart***

Graduate student, Microbiology

**Poster Title:** Carbonate formation by *Bacillus pasteurii* in  
 synthetic brine

**CBE Faculty Mentors:**

Matthew Fields, Microbiology;  
 Al Cunningham, Civil Engineering; and  
 Robin Gerlach, Chemical & Biological Engineering

**Student Presenter:**

***Jared Bozeman***

Undergraduate, Cell Biology & Neuroscience

**Poster Title:** Exploring microbial diversity in phosphate  
 mine overburden using clone libraries

**CBE Faculty Mentor:** Brent Peyton, Chemical & Biological  
 Engineering

**Student Presenter:**

***Chris Durgan***

Undergraduate, Chemical & Biological Engineering

**Poster Title:** Adsorption of metallic and organic  
 groundwater contaminants using coal-derived sorptive  
 materials

**CBE Faculty Mentor:** Paul Sturman, Civil Engineering

**Student Presenter:**

***Hilary Fabich***

Undergraduate, Chemical & Biological Engineering

**Poster Title:** Magnetic resonance analysis of physically  
 cross-linked biopolymer gels

**CBE Faculty Mentors:** Joseph Seymour and Sarah Codd,  
 Chemical & Biological Engineering

**Student Presenter:**

***Philip Gardner***

Undergraduate, Cell Biology & Neuroscience

**Poster Title:** Characterization of microbial communities  
 from a thermoalkaline spring in Yellowstone  
 National Park

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

**Student Presenter:**

***Travis Harrer***

Undergraduate, Chemical & Biological Engineering

**Poster Title:** Induced calcium carbonate deposition  
 experiments

**CBE Faculty Mentors:**

Robin Gerlach, Chemical & Biological Engineering; and  
 Al Cunningham, Civil Engineering

**Student Presenter:**

***Myles Perkins***

Undergraduate, Chemical & Biological Engineering

**Poster Title:** A collaborative effort for standardization of  
 the MBEC Assay™

**CBE Mentor:** Diane Walker, CBE

**Student Presenter:**

***Paul Popovitch***

Undergraduate, Chemical & Biological Engineering

**Poster Title:** Characterization of siderophores produced  
 by *Halomonas elongata*

**CBE Faculty Mentor:** Abigail Richards, Chemical &  
 Biological Engineering

**Student Presenter:**

***Nicole Schonenbach***

Undergraduate, Chemical Engineering

**Poster Title:** Algal growth optimization for biodiesel production

**CBE Mentors:** Brent Peyton and Rob Gardner, Chemical and Biological Engineering

**Student Presenter:**

***Michelle Tigges***

Graduate student, Microbiology

**Poster Title:** Mass spectrometry methylation of MCP chemotaxis receptors

**CBE & MSU Faculty Mentors:**

Matthew Fields, Microbiology, and  
Brian Bothner, Chemistry & Biochemistry

**Student Presenter:**

***Rachel VanKempfen-Fryling***

Graduate student, Molecular Biosciences

**Poster Title:** Microbial community analysis of constructed wetlands and floating islands

**CBE Faculty Mentor:** Anne Camper, Civil Engineering

**Student Presenter:**

***Garret Vo***

Undergraduate, Mathematics and Physics

**Poster Title:** An experimentally validated immersed boundary model of fluid-biofilm interaction

**CBE Faculty Mentor:** Jeffrey Heys, Chemical & Biological Engineering

**Student Presenter:**

***Ryan Waters***

Graduate student, Mathematics

**Poster Title:** Diffusion of lactoferrin into *Pseudomonas aeruginosa* biofilms

**CBE & MSU Faculty Mentors:**

Mary Cloud Ammons, CBE; and  
Tomas Gedeon, Mathematics

## EDUCATION:

### 2010 MSU Student Awards and Recognition

#### Sabrina Behnke

2010 W.G. Characklis Award, Center for Biofilm Engineering

#### Mari Eggers, PhD candidate, Microbiology

- PI for Little Big Horn College for two NIH sub-awards from Montana State University, Bozeman.
- Serves on the Education, Outreach and Training Committee for the National Science Foundation's iPlant initiative.
- Serves on the Advisory Committee for the American Indian Research Opportunities' NSF-URM grant, which supports Native American undergraduate scholars in ecology and environmental science degree programs.
- Served as a reviewer for NSF's TCUP program.
- Serves on the graduate Committee for Gail Whiteman, a science education masters student.

#### Erin Field

Ferguson Doctoral Student Fellowship Award (Microbiology Department)  
2010 W.G. Characklis Award, Center for Biofilm Engineering

#### Philip Gardner, undergraduate, Cell Biology and Neuroscience

MSU Award for Excellence, in the College of Letters and Science, Tuesday, February 16, 2010. Award winners name a faculty or staff mentor, who is also recognized; his mentor is CBE faculty member **Matthew Fields**, assistant professor of microbiology. Forty top seniors who are recognized by this award must be nominated by faculty in their college or department and demonstrate exceptional scholarship as well as campus leadership and community service.

#### Grant Justin

Hughes Scholar. Hughes Scholars (6 to 10 each year) represent MSU's top biomedical students. They spend a year working on their research and developing outreach opportunities that are changing the way MSU reaches its next generation of science students. Grant participated in the Hughes Scholars Symposium, April 6, 2010, presenting "The next generation: Getting high school students involved in science NOW."

#### Natasha Mallette

Served as a member of the Women in Engineering Advisory Board, which works with the EMPOWER program.

#### Trevor Zuroff, undergraduate, Chemical & Biological Engineering

**MSU Award for Excellence**, in the College of Engineering, Tuesday, February 16, 2010. Award winners name a faculty or staff mentor, who is also recognized; Trevor's mentor is CBE faculty member **Ross Carlson**, assistant professor of chemical and biological engineering. Forty top seniors who are recognized by this award must be nominated by faculty in their college or department and demonstrate exceptional scholarship as well as campus leadership and community service.

Trevor also won the 2010 **Torlief Aasheim Community Involvement Award**, the university's top award for student service. The award, named for late MSU alumnus Torlief "Torley" Aasheim, recognizes male and female senior students who, in addition to excelling academically, volunteer on campus and in the community. He has served as a captain for MSU's Relay for Life team and volunteered for the Gallatin Valley Food Bank and the Big Brothers Big Sisters organization. He has also volunteered for numerous events designed to raise kids' level of interest in the sciences, including Science Saturdays at MSU, the Montana Science Olympiad and the Montana FIRST Robotics Tournament.

Trevor received an **NSF Graduate Fellowship** (\$33,000/3yrs) to attend Penn State, as well as a **McWhirter Fellowship from Penn State**, which will provide extra financial support, plus money for undergraduate student assistants. He will be working in the laboratory of Wayne Curtis on unique methods of control & optimization of fixed-film biofilm reactors.

EDUCATION:  
 Survey of student participation

*CBE students are essential members of the Center for Biofilm Engineering. Their tireless contributions extend well beyond research and classroom work. Below we highlight the participation of CBE students in the variety of ways they help make the Center a place of excellence.*

**Current students who were authors on peer-reviewed publications this academic year**

John Aston	Mari Eggers	Natasha Mallette	Pat Secor
Kristen Brileya	Jennifer Faulwetter	James Moberly (3)	Reed Taffs
Marcus Dieser	Erin Field (2)	Liz Sandvik (2)	Mike VanEngelen (2)
Seth D'Imperio			

**Students who presented research off-campus**

Mari Eggers: STAR/GRO EPA Fellows Conference, Washington DC; COBRE-INBRE Scientific Conference, Big Sky, MT; EPA Promoting Environmental Health in Native American Communities, Washington DC  
 Lisa Kirk: Goldschmidt Geochemistry Conference, Davos, Switzerland  
 Natasha Mallette: EFRI Annual Meeting, Arlington, VA  
 Andrew Meehan: IEEE Energy Conversion Congress, San Jose, CA  
 Crystal Richards: EURObiofilms, Rome, and STAR/GRO EPA Fellows Conference, Washington, DC  
 Logan Schultz: Microscopy and Microanalysis Conference, Richmond, VA  
 Pat Secor: ASM Biofilms Meeting, Cancun, Mexico  
 Luis Serrano-Figueroa: SACNAS Conference, Dallas, TX  
 Trevor Zuroff: AIChE Conference, Nashville, TN

**Participants in MSU Research Celebration: April 2010**

Salman Adam	Chris Durgan	Myles Perkins	Rachel VanKempen-Fryling
Steven Anderson	Hilary Fabich	Paul Popovitch	Garret Vo
Elliott Barnhart	Philip Gardner	Nicole Schoenenbach	Ryan Waters
Jared Bozeman	Travis Harrer	Michelle Tigges	

**Student members of the CBE Operations Committee**

Ratalil Akabari	Natasha Mallette
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**CBE Seminar Series student organizers**

Gem Encarnacion	Kara DeLeon	Erin Field	Luis Serrano-Figueroa
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**CBE Seminar Series student presenters**

Lisa Kirk	Natasha Mallette	Anitha Sundararajan
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**MONTANA BIOFILM SCIENCE & TECHNOLOGY MEETINGS**

**Student Presenters:**

**Winter 2010**

Pat Secor

**Summer 2009**

Sabrina Behnke	Seth D'Imperio	Erin Field	Crystal Richards
Eric Brindle	Gem Encarnacion	Jennifer Hornemann	Logan Schultz
Kara De Leon	Jennifer Faulwetter		

**Poster Presenters, Winter 2010**

Elliott Barnhart	Rob Gardner	Crystal Richards	Sarah Vogt
Kristen Brileya	James Moberly	Pat Secor	Jeremy Woods
Kara De Leon	Kelly O'Shea	Luis Serrano-Figueroa	Trevor Zuroff
Erin Field	Myles Perkins	Anitha Sundararajan	

**Poster Presenters, Summer 2009**

Salman Adam	Kara De Leon	James Moberly	Jeremy Woods
Steven Anderson	Seth D'Imperio	Kelly O'Shea	Trevor Zuroff
John Aston	Mari Eggers	Anitha Sundararajan	
Kristen Brileya	Erin Field		

**Workshop Instructors**

Pat Secor	Jeremy Woods	Anitha Sundararajan
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**Workshop Volunteers**

Rati Akabari	Karen Moll	Liz Sandvik
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**Student Volunteers for Montana Biofilm Meetings**

Salman Adam	Gem Encarnacion	Natasha Mallette	Anitha Sundararajan
Rati Akabari	Loribeth Evertz	James Moberly	Reed Taffs
Sabrina Behnke	Hilary Fabich	Garret Oksness	Jeremy Woods
John Blaskovich	Jennifer Faulwetter	Liz Sandvik	Trevor Zuroff
Kara De Leon	Erin Field	Pat Secor	
Chris Durgan	Rob Gardner	Luis Serrano-Figueroa	
Mari Eggers	Travis Harrer	Heidi Smith	

***and special thanks to  
Austin Jacobs, AV***

## GRADUATE HIGHLIGHT

### ***Stronger relationships, better water***

CBE researchers are demonstrating that collaborative work can link laboratories and communities to produce relevant results.

Two CBE doctoral researchers in microbiology are investigating Montana water quality issues with the cooperation of community residents. **Mari Eggers** and **Crystal Richards**—both EPA STAR Fellowship grant awardees under the direction of Anne Camper, professor of civil engineering—work with residents collecting data in their communities to identify potential water quality problems in rural Montana water supplies.

Richards targets three known human pathogens: *Helicobacter pylori* (associated with stomach ulcers), *Legionella pneumophila* (which causes a severe respiratory ailment), and *Mycobacterium avium* (implicated in respiratory infections in immunocompromised people). *M. avium* was the only pathogen detected in Gallatin County (33% positive samples), while all three pathogens were found in Big Horn County: *H. pylori*—14% positive samples, *L. pneumophila*—41% positive samples, and *M. avium*—50% positive samples.

While Richards studies pathogens, Eggers performs complementary research on chemical exposures. She has been working with the dedicated members of the Crow Environmental Health Steering Committee, Tribal member and MSU graduate Crescentia Cummins, and a dozen Tribal College science majors over the past six years to carry out a community-based risk assessment of exposure to chemical and bacterial contaminants in water on the Crow Reservation in south central Montana. Their data have identified a number of concerns, including pollution in three rivers and bacterial and inorganic contamination of wells on the reservation. The data are being used by the community to seek funding to upgrade the water and wastewater treatment systems.

Richards credits Eggers' work with tribal community representatives for facilitating her own research experience. Said Richards, "I have met many friends along the way and have learned a lot about conducting research in a community in a culturally appropriate way."

## UNDERGRADUATE HIGHLIGHT

### ***More interdisciplinary collaboration, better design solutions***

The CBE goes to great lengths to emphasize the importance of collaborative research, but two senior undergraduates from opposite sides of the globe recently demonstrated how far they were willing to go to get successful results. Mechanical Engineering Technology (MET) majors **Salman Adam**, from Pakistan via Dubai, UAE, and **Steven Anderson**, of Gardiner, MT, recently combined their efforts in an internship with the CBE—and in the process gained valuable experience in teamwork, communication skills, and tool design skills. Their MET capstone project involved developing a set of testing tools, including a tweezer-like biofilm coupon holder that can be manufactured and sold by Biosurface Technologies (BST), a Bozeman-based company owned by Bryan Warwood. The project was supported by a grant from the Montana Board of Research and Commercialization Technology.

Adam and Anderson quickly discovered that their first challenge was to understand what biofilm is and how scientists test biofilms in a laboratory setting. Their goal was to design and construct a prototype tool set to make it easier and more efficient for laboratory technicians to perform the ASTM standard method for biofilm sampling. Helping them in the lab were members of the CBE's Standardized Biofilm Methods Laboratory: Darla Goeres, Diane Walker, Lindsey Lorenz, and Kelli Buckingham-Meyer. Their project advisor was MET instructor Kevin Cook. The development process required over 30 iterations in tool design before landing on the best option.

When asked what they learned by doing the project, Steven responded, "It was a very good interdisciplinary learning experience working with the CBE. Typically you would not see a mechanical engineer working in a microbiology lab, but understanding the laboratory procedure for the standard method was essential to the design process." To which Salman happily added, "This week when I appeared for the FE (Fundamentals of Engineering) Exam, I aced the biology section of the test!"

## EDUCATION:

CBE Seminar Series: Fall 2009

Date	Speaker	Affiliation	Topic
3-Sep	First Week of Class		No seminar
10-Sep	Garth James	Medical Biofilm Laboratory Manager, CBE-MSU	Biofilms in chronic wounds
17-Sep	Brent Peyton	Associate Professor, Chemical & Biological Eng, CBE-MSU	MSU Algal Biofuels Group: Production of algal lipids for biodiesel
24-Sep	Bob Smith	Distinguished Professor of Subsurface Science, University of Idaho, Idaho Falls	Biogeochemical modeling of ureolytically driven calcium carbonate precipitation
1-Oct	Mary Cloud Ammons	Postdoctoral Research Assistant, CBE-MSU	Lactoferrin, xylitol, and <i>Pseudomonas aeruginosa</i> biofilms
8-Oct	Zbigniew Lewandowski	Professor, Civil Engineering, CBE-MSU	From microbial corrosion to microbial fuel cells
15-Oct	Natasha Mallette	PhD Candidate, Chemical & Biological Eng., CBE-MSU	Optimizing culturing conditions for the direct conversion of biomass to mycodiesel using <i>Gliocladium roseum</i>
22-Oct	Andy Sabalowsky	Postdoctoral Research Associate, CBE-MSU	Differences in toxicity observed in suspended and biofilm growth as explained by a supermodel
29-Oct	Brett Baker	President and CEO, Microbion Biosciences Corp., Bozeman	Preclinical development of a broad spectrum antibiotic with antibiofilm properties
5-Nov	Aurelien Mazurie	Research Associate, Microbiology, Bioinformatics Core Facility, MSU	Evolution of metabolic networks organization
12-Nov	Mary Schweitzer	Associate Professor, Marine, Earth, and Atmospheric Sciences at North Carolina State	Slimy Dinosaurs: The link between extinct life and biofilms
19-Nov	5th ASM Conference on Biofilms, Cancun		No seminar
26-Nov	Thanksgiving		No seminar
3-Dec	Laura Jennings	Postdoctoral Researcher, Chemistry, MSU	Metabolomics: Applications for profiling cellular metabolites
10-Dec	Last week of class		No seminar



EDUCATION:  
 CBE Seminar Series: Spring 2010

Date	Speaker	Affiliation	Topic
14-Jan	First Week of Class	No Seminar	No seminar
21-Jan	Phil Stewart	Director, CBE	Physiology and antibiotic tolerance of <i>Pseudomonas aeruginosa</i> in biofilms as revealed by transcriptional profiling
28-Jan	pre-MBM meeting Jan 27th	No Seminar	No Seminar
4-Feb	Nick Zelter	MSU-Tech transfer	Technology Transfer — A Local Perspective
11-Feb	MBM meeting	No Seminar	No Seminar
18-Feb	Alan English	Manager, Gallatin Local Water Quality District	Assessment and distribution of pharmaceuticals and endocrine disruptors in wastewater, ground water and surface waters of the Gallatin Valley, Gallatin County, Montana
25-Feb	Lisa Kirk	PhD candidate, Land Resources & Environmental Sciences	In situ microbial selenate reduction in backfilled SE Idaho phosphate mine wastes
4-Mar	Mark Jutila	Professor, Veterinary Molecular Biology, MSU	Effects of dietary polyphenols and polysaccharides on innate lymphocytes
11-Mar	Jovanka Voyich	Assistant Professor, Veterinary Molecular Biology, MSU	Evasion of innate immunity: Strategies of community-associated MRSA
18-Mar	Spring Break	No Seminar	No Seminar
25-Mar	Tom Johnson	Associate Professor, Geology, Univ. of Illinois Urbana-Champaign	Heavy stable isotope indicators of redox processes and microbial activity
1-Apr	Anitha Sundararajan	PhD candidate, Microbiology	Pleiotropic effects caused by deletion of a sensory box gene in <i>Shewanella oneidensis</i> MR1
8-Apr	Tim Sheibe	2010 Henry Darcy Distinguished Lecturer, Staff Scientist, Hydrology	Beyond the black box: Integrating advanced characterization of microbial processes with subsurface reactive transport models
15-Apr	Doug Powell	Associate Professor, Diagnostic Medicine and Pathobiology, Kansas State	Engineering, design and culture to enhance food safety
22-Apr	Ross Carlson	Assistant Professor, Chemical and Biological Engineering, MSU	Recent developments in the Carlson Laboratory
29-Apr	Last week of classes	No Seminar	No Seminar

TECHNOLOGY TRANSFER:  
Industrial Associates, 2009–10

**3M**

**Alcon Research**

**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**

**Ethox International**

**Glanbia Nutritionals**

**GlaxoSmithKline**

**ICU Medical**

**Johnson & Johnson**

**Kane Biotech**

**Kimberly-Clark**

**Masco Corporation**

**Mölnlycke Health Care AB**

**NASA**

**Novozymes A/S**

**Procter & Gamble**

**Quiescence Technologies** (*formerly QuoNova*)

**Sandia National Laboratories**

**Semprus BioSciences**

**Sherwin-Williams**

**Unilever**

**W.L. Gore & Associates**

**Whirlpool**

TECHNOLOGY TRANSFER:  
 Technical Advisory Conference  
 July 7–9, 2009

**Monday, July 6**

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

**Tuesday, July 7**

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**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, Masco, TAC Chair  
 Phil Stewart, CBE Director

*SESSION 1:*

**Phenotypic Heterogeneity**

**8:15–8:20**  
**Session introduction**  
 Phil Stewart

**8:20–9:00**  
**Biofilms, genetic diversity, and the insurance hypothesis**  
 Pradeep Singh, Associate Professor, Microbiology, University of Washington

**9:00–9:40**  
**Distinct physiological cell-subpopulations and antimicrobial tolerance in biofilms**  
 Sünje J. Pamp, Postdoctoral Research Fellow, Microbiology & Immunity, Stanford University School of Medicine

**9:40–10:15**  
**Diverse phenotypes in biofilms: Implications for antimicrobial control**  
 Phil Stewart

**10:15–10:45 Break**

*SESSION 2:*

**Environmental Biofilms**

**10:45–10:50**  
**Session introduction**  
 Al Cunningham, Professor, Civil Engineering, CBE

**10:50–11:15**

**Image and tracer analysis of biofilm and mineral affected porous media**  
 Logan Schultz, MS Candidate, Chemical and Biological Engineering

**11:15–11:35**  
**Phase-field model of biofilm-flow interaction**  
 Tianyu Zhang, Assistant Professor, Mathematics, MSU

**11:35–12:00**  
**Organisms responsible for nitrification in drinking water**  
 Gem Encarnacion, PhD Candidate, Microbiology, CBE

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**12:00–1:10**  
**Lunch at the Hilton Garden Inn**

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*SESSION 3:*

**Dental Biofilms**

**1:10–1:15**  
**Session introduction**  
 Garth James, CBE Medical Biofilm Laboratory Manager

**1:15–2:00**  
**Microbiology of oral biofilms - present and future**  
 Rob Palmer, Natl Inst Dental Craniofacial Res – Natl Insts Health Oral Infection and Immunity Branch

**2:00–2:30**  
**Diffusion of macromolecules in model oral biofilms**  
 Phil Stewart

**2:30–3:00**  
**Environmental modulation of the in vitro antimicrobial efficacy of various oral care products on dental plaque biofilms**  
 Ositadinma Ona, Senior Microbiologist, GSK Consumer Healthcare R&D, and Raymond Ignar, Development Microbiologist, GSK

**3:00–3:30 Break**

**3:30–4:00**  
**Dental biofilm control**  
 Harsh Trivedi, Senior Technical Associate, Early Research Oral Care, Colgate-Palmolive Company,

Piscataway, NJ

**4:00–4:30**  
**An in vitro model for the study of bad breath**  
 Alessandra Agostinho, Research Scientist, CBE

**4:30–5:00**  
**Formation of communities within oral biofilms**  
 Rob Palmer

**Wednesday, July 8**

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**7:00–8:00 a.m.**  
**Biofilm Methods Advisory Committee Meeting**

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

*SESSION 4:*

**Biofilm Mechanics**

**8:00–8:30**  
**Session introduction**  
**Development of a microcantilever method for measuring the cohesive strength of biofilms**  
 Ray Hozalski, Associate Professor, Civil Engineering, University of Minnesota

**8:30–8:55**  
**Measuring changes in biofilm mechanical properties due to chemical and enzymatic treatments**  
 Eric Brindle, MS Student, Mechanical and Industrial Engineering

**8:55–9:20**  
**Modeling fluid structure interactions with application to biofilms**  
 Jeff Heys, Assistant Professor, Chemical and Biological Engineering, MSU

**9:20–9:45**  
**Magnetic Resonance Microscopy study of biofilms: Diffusion, hydrodynamics, and porous media**  
 Jennifer Hornemann, recent PhD graduate, Chemical and Biological Engineering

**9:45–10:15 Break**

*SESSION 5:*

**Industrial Biofilms**

**10:15–10:25**

**Session introduction**

Paul Sturman

**10:25–11:00**

**Monitoring biofilms in industrial applications and processes**

Michael Enzien, Sr. Research & Development Specialist, Dow Microbial Control

**11:00–11:35**

**Fouling and cleaning science: Direct detection of biofilms and CIP-related problems in liquid process systems**

Mark Fornalik, Director, Analytical Chemistry & Biofouling Science Ethox International STS Life Sciences Division

**Imaging industrial samples at the CBE: How do we do it?**

Betsey Pitts, Research Scientist and Microscope Facilities Manager

**11:35–12:00**

**Comparing the disinfection of planktonic cells, biofilms, and detached biofilm particles**

Sabrina Behnke, PhD Student, Microbiology

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**12:00–1:15**

**Lunch at the Hilton Garden Inn**

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**Special Presentation**

**1:15–1:45**

**State of the CBE Address**

Phil Stewart

**1:45 – 3:00**

**CBE Industrial Associates Business Meeting**

**Poster Session**

**& Laboratory Open House**

**3:30–5:30**

CBE Laboratories, 3rd Floor EPS Building, MSU

**6:00 – 9:00 Dinner, Catered at Rockin' TJ Ranch, Bozeman**

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**Thursday, July 9**

**7:30–8:00 a.m.**

**Registration and continental breakfast**

Hilton Garden Inn reception area

*SESSION 6:*

**Molecular Methods in Biofilm Ecology**

**8:00–8:10**

**Session introduction**

Matthew Fields, Assistant Professor, Microbiology, CBE

**8:10–8:40**

**Detection of opportunistic pathogens in drinking water and biofilms in rural Montana**

Crystal Richards, PhD Candidate, Microbiology

**8:40–9:10**

**Contaminated bulk soap dispensers: comparison of two methods of analysis**

Lindsey Lorenz, CBE Research Assistant

**9:10–9:35**

**Statistical considerations in molecular methods**

Al Parker, CBE Statistician

**9:35–10:05**

**Molecular methods for analyzing microbial function in constructed wetlands**

Jennifer Faulwetter, PhD Student, Microbiology

**10:05–10:35 Break**

**10:35–11:05**

**Rapid taxonomic classification and analysis of complex microbial communities using a microarray**

Seth D'Imperio, Postdoctoral Research Assistant, Chemical and Biological Engineering

**11:05–11:35**

**Microbial community analysis of a low-level waste site using the PhyloChip, a novel microarray**

Erin Field, PhD Candidate, Microbiology

**11:35–12:00**

**Elucidating possible relationships within bacterial community dynamics and abiotic parameters**

Kara De Leon, PhD Candidate, Microbiology

**12:00**

**Meeting Wrap up**

TECHNOLOGY TRANSFER:

Standardized Biofilm Methods Workshop

*How to grow, treat, sample, and analyze biofilm bacteria*

July 6, 2009

**9:00 – 9:15**      **Welcome – Phil Stewart, CBE Director EPS 323**

- Group introductions

*Morning Presentations:*

**9:15 – 9:45**      **An Introduction to Biofilms – Paul Sturman EPS 323**

**9:45 – 10:25**    **A Systematic Approach to Standardizing Research Methods – Darla Goeres EPS 323**

**10:25 – 10:40**    **Morning Refreshments**

**10:40 – 11:20**    **Experimental Design & Data Analysis in the Biofilm Laboratory – Al Parker EPS 323**

**11:20 - 12:00**    **Microbial Community Analysis – Brad Ramsay EPS 323**

**12:00 – 1:15**      **LUNCH – Habit Restaurant, MSU Campus**

*Afternoon Laboratory Rotations:*

	<i>Group 1</i>	<i>Group 2</i>	<i>Group 3</i>	<i>Group 4</i>	<i>Group 5</i>
<b>1:15 – 1:45</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>
<b>1:55 – 2:25</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>A</b>
<b>2:35 – 3:05</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>A</b>	<b>B</b>
<b>3:15 – 3:45</b>	<b>D</b>	<b>E</b>	<b>A</b>	<b>B</b>	<b>C</b>
<b>3:55 – 4:25</b>	<b>E</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>

*Growing, Treating, Sampling & Analyzing Biofilm Following Standard Methods:*

- A.** ASTM E2196-07 Standard Test Method for the Quantification of a *Pseudomonas aeruginosa* Biofilm Grown with Shear and Continuous Flow using Rotating Disk Reactor – Darla Goeres **EPS 337**
- B.** ASTM E2562-07 Standard Test Method for Quantification of *Pseudomonas aeruginosa* Biofilm Grown with High Shear and Continuous Flow using CDC Biofilm Reactor – Diane Walker **EPS 302**
- C.** ASTM E2647-08 Standard Test Method for Quantification of *Pseudomonas aeruginosa* Biofilm Grown Using a Drip Flow Reactor with Low Shear and Continuous Flow – Lindsey Lorenz **EPS 301**
- D.** Efficacy Testing of Biofilm Grown Following Standard Methods – Kelli Buckingham-Meyer **EPS 301**
- E.** Data Analysis – Al Parker **EPS 333**

**4:30 – 5:00**      **Wrap-Up/Discussion – EPS 323**

TECHNOLOGY TRANSFER:  
 Technical Advisory Conference  
 February 8–10, 2010

**Monday, February 8**

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

**Tuesday, February 9**

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**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, Masco, TAC Chair  
 Phil Stewart, CBE Director

*SESSION 1:*

**Industrial Water Treatment**

**8:15–8:20**  
**Session introduction**  
 Anne Camper, Professor, Civil  
 Engineering and Associate Dean,  
 College of Engineering

**8:20–8:50**  
**Keynote speaker:**  
**Biofilm control in industrial processes**  
 Laura Rice, Research Scientist, Process  
 Research, Nalco Company

**8:50–9:10**  
**Recycled/reclaimed water: Synopsis  
 of workshops**  
 Anne Camper, Professor, CBE

**9:10–9:40**  
**Biofilms in water treatment:  
 An industry perspective**  
 Ben Klayman, Water Process Engineer,  
 Black & Veatch Corporation

**9:40–10:00**  
**Extremophile survival in industrial  
 water**  
 Abigail Richards, Assistant Professor,  
 Chemical and Biological Engineering,  
 CBE

**10:00–10:30 Break**

*SESSION 2:*

**Enzymes and Biofilms**

**10:30–11:00**  
**Biofilms: If you can't beat 'em, join  
 'em**  
 Sarah McHatton, R&D Group Leader,  
 Institutional & Household Products,  
 Novozymes Biologicals, Inc.

**11:00–11:30**  
**Dispersin B antibiofilm enzyme:  
 Scientific and commercial  
 perspectives**  
 Sri Madhyastha, Chief Scientific  
 Officer, Kane Biotech, Inc.

**11:30–12:00**  
**Disruption of *Pseudomonas  
 aeruginosa* biofilms by enzymes**  
 Phil Stewart, CBE Director

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

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**1:00–1:25**  
**Next generation sequencing:  
 Implications for biofilm research**  
 Seth D'Imperio, Visiting Scientist,  
 Novozymes Biologicals, Inc.  
 (former CBE Postdoctoral Researcher)

**1:25–1:50**  
**Algal biofuels**  
 Brent Peyton, Professor, Chemical and  
 Biological Engineering; Associate  
 Director, Thermal Biology Institute

**1:50–2:20**  
**Highlights from recent biofilm  
 meetings**  
 Phil Stewart

**2:20–2:40**  
**Social evolution theory and biofilms**  
 Joao Xavier, Assistant Professor,  
 Computational Biology, Sloan-  
 Kettering Institute, New York

**2:40–3:00**  
**Regulation of toxicity in *Pseudomonas  
 aeruginosa* biofilms by the  
 magnesium transporter MgtE**  
 Gregory Anderson, Assistant Professor,  
 Indiana University- Purdue University,  
 Indianapolis

**Poster Session & Laboratory Open  
 House**

**3:30–5:30**  
 CBE Laboratories, 3rd Floor EPS  
 Building, MSU

**Wednesday, February 10**

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**7:00–8:00 a.m.**  
**Biofilms Methods Advisory  
 Committee Meeting**  
 Larkspur Ballroom

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

*SESSION 3:*

**Healthcare Associated  
 Biofilms**

**8:00–8:40**  
**Session introduction**  
**Lessons from medical device testing**  
 Garth James, CBE Medical Biofilm  
 Laboratory Manager

**8:40–9:10**  
**Making health care-associated  
 infections go away: Embracing a  
 biofilm strategy**  
 Deborah Burton, Vice President and  
 Chief Nursing Officer, Providence  
 Health & Services, Renton, WA;  
 Marly Christenson, System Director,  
 Clinical Transformation, Providence  
 Health & Services

**9:10–9:40**  
**Review of healthcare associated  
 infections (HAI) on medical devices**  
 Elinor Pulcini, Research Scientist, CBE  
 Diane Walker, Research Engineer, CBE

**9:40–10:10**  
**Vascular catheter infections. . .  
 technical challenges for industry**  
 Marcia Ryder, Consultant,  
 Ryder Science

**10:10–10:40 Break**

**10:40–11:05**

**Keratinocytes produce pro-inflammatory markers in *Staphylococcus aureus* biofilm infection**

Pat Secor, PhD candidate,  
Cell Biology, CBE

**11:05–11:30**

**Pressure ulcers: The human element**  
Karen Zulkowski, DNS, RN, CWS;  
Associate Professor, Nursing, MSU

Peter Suci, Research Assistant  
Professor, Plant Sciences & Plant  
Pathology, MSU

**11:30–11:55**

**Targeting microbial biofilms with protein cage nanoplatforms**

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## WORKSHOP:

February 7, 2010

Modifying Standardized Biofilm Methods:

*A Workshop of Different Designs*

Currently there are three biofilm methods that have been standardized through the American Society of Testing and Materials, International (ASTM). They are the:

- CDC biofilm reactor (CBR—ASTM Method #2562)
- rotating disk reactor (RDR—ASTM Method #2196)
- drip flow reactor (DFR—ASTM Method #2647)

These methods are used to grow a *Pseudomonas aeruginosa* biofilm under high, medium and low shear forces, respectively. But what if you're interested in anaerobes like *Desulfovibrio vulgaris* or you have a silver-embedded catheter that you'd like to test under low shear conditions? How would you modify the standard method to meet your research needs? This workshop will demonstrate what scientists at the CBE are doing, and hopefully provide some answers and spark some ideas to help with your projects.

## OUTREACH:

### Visitors

**Anozie Ebigbo**, recent PhD graduate of the University of Stuttgart, Germany, worked at the CBE on multi-phase modeling of supercritical CO<sub>2</sub>, brine, biofilms, and biominerals in the deep subsurface. Anozie ran experiments in the lab and continued his computer modeling work at MSU during the month of November 2009. Anozie's faculty host was Al Cunningham.

**Mariana Fittipaldi**, a visiting PhD candidate from the Laboratorio de Microbiologia Sanitaria y Medioambiental, Universitat Politècnica de Catalunya, Barcelona Spain, was invited by faculty member Anne Camper to work in the Industrial & Environmental Water Systems laboratory from April 2009 through August 2009.

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

**Anna Heinkel**, visiting undergraduate from the University of Duisburg-Essen in Germany, worked on research contributing to her Bachelor's thesis in the Industrial & Environmental Water Systems laboratory from April 2009 to August 2009. Her faculty host was Anne Camper.

**Mijeong Jang**, a visiting postdoctoral scientist from Seoul, Korea, was invited by faculty member Anne Camper to work at the CBE for one year 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.

**Liz Johnson**, visiting postdoctoral researcher in Mary Schweitzer's lab at North Carolina State University (see below), worked was hosted by Robin Gerlach to study at the CBE from October through December 2009. Liz studies the fossilization process of dinosaur bones and tissues. **Mary Schweitzer**, Associate Professor in Marine, Earth, and Atmospheric Sciences at North Carolina State University, received her PhD from MSU Bozeman in 1995 and has since spent many summers at MSU, working with the Museum of the Rockies, ICAL, and other units. Mary's research interests are in the area of molecular paleontology, specifically the mechanisms for preservation of tissues in fossils. She presented a seminar on her work in the fall of 2009.

**Reiko Kariyama**, a returning visitor from Japan, came for a short-term visit in July 2009, to attend the summer 2009 Montana Biofilm Meeting and to learn new techniques in the lab. Her faculty host was Phil Stewart.

**Danielle Kinsey**, an undergraduate student at Fort Belknap College, worked in Matthew Fields' lab in the summer of 2009 as part of the American Indian Research Opportunities (AIRO) BRIDGES program. She worked with Kristen Brileya on methanogenic cultures.

**Emma Mean**, visiting undergraduate from Notre Dame University, was invited by faculty member Christine Foreman to study at the CBE from June 2009 through August 2009. She also participated as a volunteer during the summer 2009 Montana Biofilm Meeting.

**Maria Nikolopoulou**, visiting PhD candidate from Technical University of Crete in Chanix, Greece, was invited by faculty member Brent Peyton, to spend a month at the CBE from July to August 2009.

**Patricia Peters**, visiting undergrad from the University of Duisburg-Essen in Germany, April 2009 to August 2009, worked with Keith Cooksey, MSU microbiology, on her Bachelor's thesis.

**Esther Rosenbrand**, MS candidate from the University of Stuttgart, Germany, was invited by Al Cunningham for a short-term visiting research experience at the CBE during November 2009,

**Federica Villa** was invited by faculty member Phil Stewart to work at the CBE from April through August 2009. Federica is a visiting graduate student from the University of Milan where she is pursuing a doctorate in the Department of Food Science, Technology, and Microbiology. She studied the anti-fouling properties of a chemical isolated from a marine plant against bacterial and fungal biofilms. She presented a poster based on her CBE research at the summer Montana Biofilm Meeting: "Efficacy of zosteric acid against *Candida albicans* biofilm."

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.

**Kenichi Yoshida**, visiting administrator from Ibaraki Prefecture, Japan, participated in the CBE under the direction of faculty member Christine Foreman from June 2009 to October 2009, as part of the MSU LEAP Internship project in the Office of International Programs. Kenichi researched the CBE's visitor program administration, created a survey to determine visitor satisfaction ratings, and made recommendations to improve our program.



## FACILITIES:

### Center for Biofilm Engineering Facilities Overview

The CBE moved into the MSU's Engineering/Physical Sciences Building when it was built in 1997. The >20,000 ft<sup>2</sup> 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 the 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 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, which are used for transmitted light and epi-fluorescent imaging of biofilms. 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. One of the microscopes uses manually switched filter blocks for epi-fluorescence and the other uses an electronically controlled filter wheel and shutter. 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 Leica CM 1850 cryostat which is used to cut very thin sections (usually 5 micrometers) of frozen biofilm.

The **Confocal Microscopy Lab** contains two Leica upright Confocal Scanning Laser Microscopes (CSLM). The Leica configuration is ideal for continuous monitoring of biofilm formation and detachment phenomena because it causes only minimal specimen damage due to heating and allows for high-resolution time-lapse monitoring of the biofilm. 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 each 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 three-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.

Our TCS-NT confocal has three laser lines available for fluorescence excitation: 488, 568 and 633 nm. The second confocal system is a Leica TCS-SP2 AOBS with an add-on: a Spectra Physics MaiTai 2-photon infra-red laser and detector. With this system we can image a biofilm, then switch between AOBS confocal mode and 2-photon mode—we only need to switch detectors and lasers. The AOBS system uses no excitation or emission filters, so it offers extreme flexibility in wavelength selection; it includes seven available laser lines for excitation (458, 476, 488, 496, 514, 543 and 633nm). The MaiTai gives us still another unique imaging capability. It has been established that in tissue-like materials 2-photon imaging provides much greater resolution, especially in the z-direction. We have seen that the MaiTai can image biofilms three to four times deeper than the AOBS or any other 1-photon confocal.

The **Microscope Resource Room / Digital Imaging Lab** is where CBE researchers examine and reconstruct the stacks of image data they have collected 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 personal computers 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 computational PCs, and a computational server 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 five full-time research scientists, three technicians, one graduate student, and four undergraduate research assistants.

Activity in the MBL has expanded substantially during recent years. Seventeen companies, including CBE Industrial Associates, currently sponsor MBL projects. The MBL is also performing research in support of two NIH-funded grants. Projects include examining the role of biofilms in chronic wound infections, evaluating biofilm formation on biomaterials,

and testing medical devices. 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 (SBM) was designed to meet research and industry needs for standard analytical methods to evaluate innovative biofilm control technologies. SBM staff and students develop, refine, and publish quantitative methods for growing, treating, sampling, and analyzing biofilm bacteria. The SBM members work with international standard setting organizations on the approval of biofilm methods by the standard setting community. Under a contract with the U.S. Environmental Protection Agency (EPA), the SBM will conduct laboratory research to support the development and standardization of test methods for measuring the performance of antimicrobial products—including those for biofilm bacteria—and provide statistical services related to EPA's Office of Pesticide Programs Antimicrobial Testing Program. In addition, they 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. SBM 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  $\mu\text{m}$  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
- \* Microplotting 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>