# 2008 APPENDIX

*to the*

*Center for Biofilm Engineering*

*Annual Report*

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2007 Publications


2008 Publications


PRESENTATIONS:  
June 1 – December 31, 2007

John Lennox and Jeffrey Ashe presented the poster “Biofilms as biobarriers,” 14th Annual American Society for Microbiology Conference for Undergraduate Educators, University at Buffalo, SUNY North Campus, Buffalo, NY, May 18–20, 2007. John Lennox is from Penn State Altoona and is co-editor on Biofilms: The Hypertextbook, an NSF-funded education project. They also presented the poster at the American Society for Microbiology General Meeting, Metro Toronto Convention Centre, Toronto, Ontario, Canada, May 21–25, 2007.


Melinda Clark presented the poster “Structural role for flagella in biofilm formation and stability in Desulfovibrio vulgaris Hildenborough,” 2007 Environmental Subsurface Science Symposium, Utah State University, Logan, Utah, July 25, 2007. She won second place in the poster competition.


Chiachi Hwang presented the poster “Changes in microbial community structure during bio-stimulation for uranium reduction,” 2007 Environmental Subsurface Science Symposium, Utah State University, Logan, Utah, July 25, 2007. She won third place in the poster competition.


Anitha Sundararajan presented the poster “Proteins involved in oxygen sensing and metabolism are important for biofilms in Shewanella oneidensis MR-1,” 2007 Environmental Subsurface Science Symposium, Utah State University, Logan, Utah, July 25, 2007.

Phil Stewart presented “Diffusion of macromolecules and antimicrobial agents in biofilm,” at the National Institute for Dental and Craniofacial Research, Bethesda, Maryland, July 27, 2007.


Markus Dieser presented the poster “Microbial diversity and the role of bacterial pigments as cryo- or UV- protectants in Pony Lake, Antarctica,” Society of International Limnology Meeting, Montreal, Canada, August 12–18, 2007. Authors: Dieser M, and Foreman C. Markus won best student poster presentation and received a $250 award.


Amber Broadbent presented the poster “Quantifying velocity and mass transfer in Taylor-Couette flow,” 9th International Conference on Magnetic Resonance Microscopy, Aachen, Germany, September 3–7, 2007. She won the conference poster award. She competed against 125 other posters and was awarded nuclear magnetic resonance textbook.


Anne Camper presented a WEBINAR: “Water quality: Biofilm formation in clean water lines,” September 13, 2007. The Webinar was sponsored by the Cosmetic, Toiletry and Fragrance Association (CTFA) and there were approximately fifty participants.

Storm Shirley and Brent Peyton presented a poster “Use of inosine containing primers for rapid resolution of microbial diversity from thermophilic hot springs in Yellowstone National Park,” Thermophiles Conference, Bergen City, Norway, September 24–27, 2007.


Phil Stewart presented “Alternative strategies to controlling biofilms,” Colgate-Palmolive symposium, Boston, Massachusetts, October 8–11, 2007.

Phil Stewart presented “Biofilms, daptomycin, and persistent infections,” Cubist Pharmaceuticals, Boston, Massachusetts, October 9, 2007.

Darla Goeres presented “Understanding the importance of biofilm in treated recreational water venues,” Texas Environmental Health Association Annual Educational Conference, Austin, Texas, October 18, 2007.


John Lennox and Jeffrey Ashe presented the poster “Biofilms as biobarriers” at the National Association of Biology Teachers, Professional Development Conference, Hyatt Regency, Atlanta, Georgia, November 28–December 1, 2007. John Lennox is from Penn State Altoona and is co-editor on Biofilms: The Hypertextbook, an NSF-funded education project.

PRESENTATIONS: January 1–May 31, 2008

Zbigniew Lewandowski presented “The concept of stratified biofilms relates results of measurements at the microscale to the biofilm reactor performance at the macroscale,” Biofilm Technologies Conference, International Water Association, Singapore, January 8–10, 2008. He also was co-chair of Session 1: Biofilm Structure along with Dr. Sanjay Swarup, National University of Singapore, Singapore.


Stewart Clark presented the poster “Comparing the behavior of Salmonella typhimurium: Biofilm vs. planktonic,” MSU Department of Graduate Studies Molecular Bioscience Recruitment Program, Bozeman, Montana, February 29, 2008.


Andy Mitchell and Robin Gerlach presented the poster “Bioremediation and the role of mixed pollution: TNT and Cr(VI),” MSU Department of Graduate Studies Molecular Bioscience Recruitment Program, Bozeman, Montana, February 29, 2008. Authors: Ballor NR, Gerlach, R.


Catherine VanEngelen presented the poster “Alkaline hydrolysis and biotransformation of TNT by thermoalkaliphiles from Yellowstone National Park,” MSU Department of Graduate Studies Molecular Bioscience Recruitment Program, Bozeman, Montana, February 29, 2008. Authors: Albaugh-VanEngelen C, Peyton BM, Gerlach R.


Phil Stewart presented a three-day workshop on biofilm control at the University of Concepción in Concepción, Chile, April 7–9, 2008. This event was a continuation of interaction between the CBE and the biofilm group in Concepción led by Homero Urrutia. The two groups have hosted reciprocal workshops and visits regularly since 2001. Dr. Stewart lectured to approximately 40 attendees on topics of: issues in biofilm control, antimicrobial tolerance in biofilms, and alternative strategies for biofilm control.

Kelly Kirker presented “Staphylococcus aureus biofilms prevent scratch wound closure in vitro,” at the Society Advance Wound Care Meeting San Diego, California, April 24–27, 2008.

Elinor deLancey Pulcini presented “Biofilms and the biodiversity of slime,” at the American Society for Clinical Laboratory Scientists (ASCLS), Idaho Spring Convention, Pocatello, Idaho, April 17–19, 2008.

Phil Stewart was invited to present “Quorum sensing inhibition as an alternative biofilm control strategy,” at Ecolab in Eagan, Minnesota, May 8, 2008.

Zbigniew Lewandowski was invited as a keynote speaker to present “Quantifying mass transport, structure, and microbial activity in biofilms,” at The First Israeli Conference on Biofilms in Water and Food Industries," Israel Institute of Technology, Technion, Haifa, Israel, May 15, 2008.
## RESEARCH : PROJECTS

### 2007–2008 CBE Research Projects

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<tr>
<th>Research Area</th>
<th>Title</th>
<th>Principal Investigator</th>
<th>Funding Agency</th>
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<tbody>
<tr>
<td>Biofilm Control / Antimicrobials</td>
<td>Kodak antimicrobial surface patent Development</td>
<td>Camper, Stewart Sturman</td>
<td>Kodak</td>
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<tr>
<td>Bioelectrochemistry</td>
<td>Microbial fuel cells to power submersed electronic devices</td>
<td>Lewandowski</td>
<td>ONR</td>
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<tr>
<td>Bioremediation</td>
<td>Subsurface biofilm barriers for enhanced geologic sequestration of supercritical CO₂</td>
<td>Cunningham Spangler</td>
<td>DOE/ZERT</td>
</tr>
<tr>
<td>Bioremediation</td>
<td>Mechanistically based field scale models of uranium biogeochemistry from up-scaling pore-scale experiments and models</td>
<td>Seymour Codd</td>
<td>DOE</td>
</tr>
<tr>
<td>Bioremediation</td>
<td>Mobility of source zone heavy metals and radionuclides: The mixed roles of fermentative activity on fate and transport of U and Cr</td>
<td>Gerlach Peyton</td>
<td>DOE</td>
</tr>
<tr>
<td>Bioremediation</td>
<td>Seasonal, operational, and plant effects on oxygen potential and microbial responses influencing constructed wetland performance</td>
<td>Stein</td>
<td>USDA</td>
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<tr>
<td>Bioremediation</td>
<td>Biocomplexity: Biogeochemical cycling of heavy metals²</td>
<td>Peyton</td>
<td>NSF</td>
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<tr>
<td>Bioremediation</td>
<td>INRA subsurface biotechnology and bioremediation research initiative</td>
<td>Cunningham</td>
<td>INRA</td>
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<td>Bioremediation</td>
<td>Identification of molecular and cellular responses of Desulfovibrio vulgaris biofilms under culture conditions relevant to field conditions for bioreduction of heavy metals</td>
<td>Fields</td>
<td>DOE</td>
</tr>
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<td>Bioremediation</td>
<td>Genome sequencing of multiple Anaeromyxobacter species: Comparative genomics for insight into the ecophysiology, genetics and evolution of metal-reducing and halorespiring bacteria</td>
<td>Fields</td>
<td>DOE</td>
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<td>Subsurface biotechnology</td>
<td>Fields</td>
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<td>Education</td>
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<td>Cunningham Ross</td>
<td>NSF</td>
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<tr>
<td>Education</td>
<td>Partners in Science Program</td>
<td>Pulcini</td>
<td>MJ Murdock Charitable Trust</td>
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<tr>
<td>Industrial and Environmental Water Systems</td>
<td>Health implications of biofilms in drinking water systems</td>
<td>Camper Cunningham</td>
<td>DOD/ARO</td>
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<td>Research Area</td>
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<td>Industrial and Environmental Water Systems</td>
<td>Towards sustainable materials for drinking water infrastructure</td>
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<td>NSF</td>
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<td>Industrial and Environmental Water Systems</td>
<td>Synthesis document on the state of science of molecular techniques for application to the drinking water industry</td>
<td>Camper Burr Nocker</td>
<td>AwwaRF</td>
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<td>Industrial and Environmental Water Systems</td>
<td>Biodegradation of HAAs in distribution systems</td>
<td>Camper</td>
<td>AwwaRF via University of Minnesota</td>
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<td>Industrial and Environmental Water Systems</td>
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<td>AwwaRF via University of Minnesota</td>
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<td>AwwaRF via Virginia Tech</td>
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<td>Medical Biofilms</td>
<td>The role of biofilms in the pathogenesis of otorrhea</td>
<td>Stewart</td>
<td>NIH via Allegheny-Singer</td>
</tr>
<tr>
<td>Medical Biofilms</td>
<td><em>Staphylococcus aureus</em> and production of toxic shock syndrome toxin</td>
<td>Lewandowski</td>
<td>Procter &amp; Gamble</td>
</tr>
<tr>
<td>Medical Biofilms</td>
<td>Transcutaneous devices permitting skin cell attachment</td>
<td>Stewart James</td>
<td>NIH via University of Washington</td>
</tr>
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<td>Medical Biofilms</td>
<td>Mobilization of <em>Candida albicans</em> biofilms</td>
<td>Suci</td>
<td>NIH</td>
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<td>Non-invasive clinical device that is effective in clearing persistent infections in prosthetic knee implants</td>
<td>McLeod</td>
<td>Allegheny-Singer MTBRC</td>
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<tr>
<td>Medical Biofilms</td>
<td>Novel chemical analysis of the biofilm-biomaterial interface</td>
<td>Carlson</td>
<td>NIH via University of Illinois</td>
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<td>Natural Organic Matter</td>
<td>Collaborative proposal: Biogeochemistry of dissolved organic matter in Pony Lake, Ross Island⁴</td>
<td>Foreman</td>
<td>NSF</td>
</tr>
<tr>
<td>Natural Organic Matter</td>
<td>Paleorecords of biotic and abiotic particles in polar ice cores³</td>
<td>Foreman Priscu</td>
<td>NSF</td>
</tr>
<tr>
<td>Physiology &amp; Ecology</td>
<td>A genomes-to-geochemical analysis of geothermal features in Yellowstone National Park⁴</td>
<td>Gerlach, Peyton, Inskeep, McDermott, Fields</td>
<td>NASA</td>
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<tr>
<td>Physiology &amp; Ecology</td>
<td>Biocomplexity in metal contaminated sediments of Lake Coeur d'Alene²</td>
<td>Peyton</td>
<td>NSF</td>
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<tr>
<td>Physiology &amp; Ecology</td>
<td>Bacterial pigments: Examining their potential role as cryo- and ultraviolet radiation protectants</td>
<td>Foreman</td>
<td>MSGC-NASA</td>
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<td>Physiology &amp; Ecology</td>
<td>Virtual Institute for Microbial Stress &amp; Survival</td>
<td>Fields</td>
<td>Lawrence Berkeley National Lab</td>
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<td>Physiology &amp; Ecology</td>
<td>Methanogenesis in subglacial environments --- biosignatures of extraterrestrial life</td>
<td>Mitchell</td>
<td>MSGC-NASA</td>
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### RESEARCH : PROJECTS

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>PI</th>
<th>Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physiology &amp; Ecology</td>
<td>Metabolic engineering of <em>Alicyclobacillus acidocaldarius</em> for lactic acid production from biomass derived Monosaccharides</td>
<td>Carlson</td>
<td>INL</td>
</tr>
<tr>
<td>Standardized Biofilm Methods</td>
<td>Antimicrobial test methodology</td>
<td>Goeres</td>
<td>EPA</td>
</tr>
<tr>
<td>Standardized Biofilm Methods</td>
<td>Research support for the development and manufacturing of a rapid biofilm analysis test kit</td>
<td>Goeres Cunningham</td>
<td>MTBRC</td>
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<tr>
<td>Structure-Function</td>
<td>Gene expression in <em>Pseudomonas aeruginosa</em> during biofilm development&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Franklin</td>
<td>NIH</td>
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<tr>
<td>Structure-Function</td>
<td>ADVANCE Fellows Award: NMR microscopy of structure-function relationships and microfluidics in biofilms and cellular suspensions&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Codd</td>
<td>NSF</td>
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<tr>
<td>Structure-Function</td>
<td>Cohesive strength and detachment of bacterial biofilms</td>
<td>Stewart</td>
<td>NSF via University of Minnesota</td>
</tr>
</tbody>
</table>

<sup>1</sup> 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
<sup>4</sup> MSU Thermal Biology Institute

### List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARO</td>
<td>Army Research Office</td>
</tr>
<tr>
<td>AwwaRF</td>
<td>American Water Works Association Research Foundation</td>
</tr>
<tr>
<td>DOD</td>
<td>U.S. Department of Defense</td>
</tr>
<tr>
<td>DOE</td>
<td>U.S. Department of Energy</td>
</tr>
<tr>
<td>EPA</td>
<td>U.S. Environmental Protection Agency</td>
</tr>
<tr>
<td>INL</td>
<td>Idaho National Lab</td>
</tr>
<tr>
<td>INRA</td>
<td>Inland Northwest Research Alliance</td>
</tr>
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<td>MSGC</td>
<td>Montana Space Grant Consortium</td>
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<tr>
<td>MTBRC</td>
<td>Montana Board of Research and Commercialization</td>
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<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>NIH</td>
<td>National Institutes of Health</td>
</tr>
<tr>
<td>NSF</td>
<td>National Science Foundation</td>
</tr>
<tr>
<td>ONR</td>
<td>Office of Naval Research</td>
</tr>
<tr>
<td>ORNL</td>
<td>Oak Ridge National Laboratory</td>
</tr>
<tr>
<td>TBI</td>
<td>Thermal Biology Institute (MSU)</td>
</tr>
<tr>
<td>USDA</td>
<td>U.S. Department of Agriculture</td>
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<tr>
<td>ZERT</td>
<td>Zero Emissions Research and Technology</td>
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## 2007–2008 Current Research Collaborators

<table>
<thead>
<tr>
<th>Collaborators</th>
<th>Title</th>
<th>PI, Research Area</th>
<th>Funding Agency</th>
<th>Project Dates</th>
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<tbody>
<tr>
<td>Ray Hozalski, University of Minnesota</td>
<td>Cohesive strength and detachment of bacterial biofilms</td>
<td>Stewart, Structure-Function</td>
<td>NSF</td>
<td>9/1/07–8/31/10</td>
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<tr>
<td>Ray Hozalski, University of Minnesota</td>
<td>Biodegradation of HAAs in distribution systems</td>
<td>Camper, Industrial and Drinking Water</td>
<td>AwwaRF via Univ of Minnesota</td>
<td>1/9/06–2/22/09</td>
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<tr>
<td>Ray Hozalski, University of Minnesota</td>
<td>Investigation of the mode of action of stannous chloride as an inhibitor of lead corrosion</td>
<td>Camper, Industrial and Drinking Water</td>
<td>AwwaRF via Univ of Minnesota</td>
<td>1/1/06–1/1/09</td>
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<td>Phil Fleckman, John Olerud, University of Washington</td>
<td>Transcutaneous devices permitting skin cell attachment</td>
<td>Stewart, James Medical Biofilms</td>
<td>NIH via Univ of Washington</td>
<td>5/1/05–4/30/07</td>
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<tr>
<td>Adam Arkin, Terry Hazen, Jay Keasling, Lawrence Berkeley National Lab, CA</td>
<td>Virtual institute for microbial stress and survival</td>
<td>Fields, Physiology &amp; Ecology</td>
<td>Lawrence Berkeley National Lab</td>
<td>10/1/07–9/30/12</td>
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<td>James Gossett, Cornell University, NY</td>
<td>Advisor to Laura Jennings</td>
<td>Bioremediation</td>
<td>Cornell University</td>
<td>09/15/05–</td>
</tr>
<tr>
<td>Marc Edwards, Virginia Polytechnic</td>
<td>Effect of nitrification on corrosion in the distribution system</td>
<td>Camper, Industrial and Drinking Water</td>
<td>AwwaRF via Virginia Tech</td>
<td>1/1/07–8/31/08</td>
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<td>William Apel, Brady Lee, Idaho National Laboratory</td>
<td>Mobility of source zone heavy metals and radionuclides: The mixed roles of fermentative activity on fate and transport of U and Cr</td>
<td>Gerlach, Peyton, Bioremediation</td>
<td>DOE</td>
<td>12/15/06–12/14/08</td>
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<tr>
<td>Brady Lee, Frank Roberto, Idaho National Laboratory</td>
<td>Metabolic engineering of <em>Alicyclobacillus acidocaldarius</em> for lactic acid production from biomass derived monosaccharides</td>
<td>Carlson, Physiology &amp; Ecology</td>
<td>INL</td>
<td>2/26/08–12/31/10</td>
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<td>Luke Hanley, University of Illinois</td>
<td>Novel chemical analysis of the biofilm-biomaterial interface</td>
<td>Carlson, Medical Biofilms</td>
<td>NIH via Univ of Illinois</td>
<td>7/16/07–4/30/09</td>
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<td>Phil Jardine, Oak Ridge National Laboratory, TN Tracy Bank, University of Buffalo, NY</td>
<td>Effects of groundwater chemistry on the distribution of soil microorganisms in natural media</td>
<td>Fields, Bioremediation</td>
<td>ORNL</td>
<td>3/8/07–9/30/09</td>
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<tr>
<td>Phil Fleckman, John Olerud, University of Washington Randy Wolcott, Southwest Regional Wound Care Center</td>
<td>Healing chronic wounds by controlling microbial biofilm</td>
<td>Stewart, James, Medical Biofilms</td>
<td>NIH</td>
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<td>Haluk Beyenal, Washington State University</td>
<td>Microbial fuel cells to power submersed electronic devices</td>
<td>Lewandowski, Bioelectrochemistry</td>
<td>ONR</td>
<td>12/15/05–6/30/09</td>
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<tr>
<td>Zhili He, Jizhong Zhou, University of Oklahoma</td>
<td>Rapid deduction of stress pathways in metal reducing bacteria</td>
<td>Fields, Bioremediation</td>
<td>DOE</td>
<td>3/1/07–2/29/09</td>
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<tr>
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<tr>
<td>Jizhong Zhou, University of Oklahoma Judy Wall, University of Missouri</td>
<td>Identification of molecular and cellular responses of <em>Desulfovibrio vulgaris</em> biofilms under culture conditions relevant to field conditions for bioreduction of heavy metals</td>
<td>Fields, Bioremediation</td>
<td>DOE</td>
<td>1/2/07–9/14/08</td>
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<td>Ron Sims, Utah State University Steve Billingsley, Inland Northwest Research Alliance, ID</td>
<td>INRA subsurface biotechnology and bioremediation research initiative</td>
<td>Cunningham, Bioremediation</td>
<td>INRA</td>
<td>6/1/06–5/31/08</td>
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<td>Garth Ehrlich, Allegheny Singer Research Institute</td>
<td>The role of biofilms in the pathogenesis of otitis media</td>
<td>Stewart, Medical Biofilms</td>
<td>NIH via Allegheny-Singer</td>
<td>12/1/03–11/30/08</td>
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<td>8/1/07–7/31/09</td>
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- **INRA** Inland Northwest Research Alliance
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- **MTBRC** Montana Board of Research and Commercialization
- **NASA** National Aeronautics and Space Administration
- **NIH** National Institutes of Health
- **NSF** National Science Foundation
- **ONR** Office of Naval Research
- **ORNL** Oak Ridge National Laboratory
- **TBI** Thermal Biology Institute (MSU)
- **USDA** U.S. Department of Agriculture
- **ZERT** Zero Emissions Research and Technology
## RESEARCH: ASSOCIATED FACULTY

### CBE Associated Faculty and Their Specialties, 2007–2008

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<tr>
<th>NAME</th>
<th>DEPARTMENT</th>
<th>SPECIALTY</th>
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<tr>
<td>Mark Burr</td>
<td>Land Resources &amp; Environ Sciences</td>
<td>Microbial community analysis</td>
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<tr>
<td>Anne Camper</td>
<td>Civil Engineering</td>
<td>Biofilms in environmental systems</td>
</tr>
<tr>
<td>Ross Carlson</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Metabolic engineering, metabolic networks</td>
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<tr>
<td>Sarah Codd</td>
<td>Mechanical &amp; Industrial Engineering</td>
<td>Magnetic resonance imaging</td>
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<tr>
<td>Al Cunningham</td>
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<td>Subsurface biotechnology and bioremediation</td>
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<tr>
<td>Jack Dockery</td>
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<td>Matthew Fields</td>
<td>Microbiology</td>
<td>Physiology and ecology</td>
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<td>Tim Ford</td>
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<tr>
<td>Christine Foreman</td>
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<td>Michael Franklin</td>
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<td>Molecular genetics, gene expression, alginate</td>
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<tr>
<td>Gill Geesey</td>
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<td>Molecular and cellular interactions at interfaces</td>
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<td>Robin Gerlach</td>
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<td>Darla Goeres</td>
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<td>Standardized biofilm methods</td>
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<td>Marty Hamilton</td>
<td>Statistics</td>
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<tr>
<td>Tom Hughes</td>
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<td>Fluorescent proteins, genetically encoded biosensors</td>
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<td>Garth James</td>
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<td>M.M. Taimur Khan</td>
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<td>Isaac Klapper</td>
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<td>Zbigniew Lewandowski</td>
<td>Civil Engineering</td>
<td>Microsensors, chemical gradients, biofilm structure</td>
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<tr>
<td>Tom Livinghouse</td>
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<td>Timothy McDermott</td>
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<td>Bruce McLeod</td>
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<td>David Miller</td>
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<td>Andreas Nocker</td>
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<td>Barry Pyle</td>
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<td>Abbie Richards</td>
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<td>Rocky Ross</td>
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<td>Web-based, active learning education</td>
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<td>Joseph Seymour</td>
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<td>Otto Stein</td>
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<td>Phil Stewart</td>
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<td>Paul Sturman</td>
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<td>Peter Suci</td>
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**EDUCATION: UNDERGRADUATE STUDENTS**

**Undergrads: Summer 2007, Fall 2007, Spring 2008**

<table>
<thead>
<tr>
<th>#</th>
<th>Last Name, First Name (Instructor)</th>
<th>Gender</th>
<th>Major</th>
<th>Location</th>
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<tr>
<td>1</td>
<td>Akabari, Ratilal (Z. Lewandowski)</td>
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<td>2</td>
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<td>California</td>
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<td>3</td>
<td>Alniemi, Saba (E. Pulcini)</td>
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<td>14</td>
<td>Hartman, Andrea (E. Pulcini)</td>
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<td>20</td>
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<td>M</td>
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<td>21</td>
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<td>22</td>
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<td>23</td>
<td>Jara, Mateo (R. Ross)</td>
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<td>Williamson, JeriLynn (B. Peyton)</td>
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Graduating Fall 2007/Spring/Summer 2008
Saba Alniemi, May 31, 2008
Shannon Goeres, May 31, 2008
Andrea Hartman, December 14, 2007
Stacey Hellekson, May 31, 2008
Bryan Helzer, May 31, 2008
Alex Hilyard, May 31, 2008
Kathryn Hoyt, December 14, 2007
Jonathan Rice, December 14, 2007
Logan Schultz, May 31, 2008

Undergraduates Summary: 2007-2008

<table>
<thead>
<tr>
<th>Discipline / Program</th>
<th>Male</th>
<th>Female</th>
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<td><strong>16</strong></td>
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</table>
### EDUCATION: GRADUATE STUDENTS

#### 1. Aldrich, Steve (MS Candidate, R. Ross)  
M  
Chem & Bio Eng  
Bozeman, MT

#### 2. Bowen, Kara (PhD Candidate, M. Fields)  
F  
Molecular Biosci  
Bozeman, MT

#### 3. Brileya, Kristen (PhD Candidate, M. Fields)  
F  
Microbiology  
Bozeman, MT

#### 4. Chambless, Jason (PhD Candidate, P. Stewart)  
M  
Chem & Bio Eng  
Austin, TX

#### 5. Clark, Melinda (PhD Candidate, M. Fields)  
F  
Microbiology  
Beloit, OH

#### 6. Clark, Stewart (PhD Candidate, A. Camper)  
M  
Microbiology  
South Africa

#### 7. Davison, William (PhD Candidate, P. Stewart)  
M  
Chem & Bio Eng  
Ballantine, MT

#### 8. Dieser, Markus (PhD Candidate, C. Foreman)  
M  
Land Res & Env Sci  
Walchsee, Austria

#### 9. Encarnacion, Gem (PhD Candidate, A. Camper)  
F  
Microbiology  
The Philippines

#### 10. Faulwetter, Jennifer (PhD Candidate, M. Burr)  
F  
Microbiology  
Morgan Hill, CA

#### 11. Field, Erin (PhD Candidate, R. Gerlach)  
F  
Microbiology  
Deep River, CT

#### 12. Fridjonsson, Einar (PhD Candidate, J. Seymour)  
M  
Chem & Bio Eng  
Iceland

#### 13. Grabinski, Kevin (PhD Candidate, A. Camper)  
M  
Civil Engineering  
East Helena, MT

#### 14. Hornemann, Jennifer (PhD Candidate, S. Codd)  
F  
Chem & Bio Eng  
Bozeman, MT

#### 15. Hwang, Chiachi (PhD Candidate, M. Fields)  
F  
Microbiology  
Taiwan

#### 16. Jennings, Laura (PhD Candidate, A. Cunningham)  
F  
Civil Engineering  
Helena, MT

#### 17. Karmacharya, Amresh (PhD Candidate, Z. Lew)  
M  
Microbiology  
Nepal

#### 18. Kirk, Lisa (PhD Candidate, B. Peyton)  
F  
Land Res & Env Sci  
Bozeman, MT

#### 19. Klayman, Benjamin (PhD Candidate, A. Camper)  
M  
Civil Engineering  
San Diego, CA

#### 20. Mallette, Natasha (PhD Candidate, R. Gerlach)  
F  
Chem & Bio Eng  
Fayetteville, AR

#### 21. O'Shea, Kelly (PhD Candidate, M. Fields)  
F  
Molecular Biosci  
Colorado Spg CO

#### 22. Rahman, Mohammad Shahedur (PhD, A. Camper)  
M  
Civil Engineering  
Rangpur, Bangladesh

#### 23. Secor, Pat (PhD Candidate, E. Pulcinii)  
M  
Cell Bio & Neurosci  
Bozeman, MT

#### 24. Shirley, Storm (PhD Candidate, B. Peyton)  
M  
Microbiology  
Belgrade, MT

#### 25. Sundararajan, Anitha (PhD Candidate, M. Fields)  
F  
Microbiology  
India

#### 26. Van Engelen, Catherine (PhD Candidate, B. Peyton)  
F  
Chem & Bio Eng  
Lake City, PA

#### 27. Van Engelen, Michael (PhD Candidate, B. Peyton)  
M  
Chem & Bio Eng  
Spokane, WA

---

### 18. Wheeler, Laura (MS Candidate, A. Cunningham)  
F  
Chem & Bio Eng  
Helena, MT
Graduate Students, 2007–2008

1:  Cell Biology & Neuroscience

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

**13: Chemical & Biological Engineering**

**MS:** 5 Barua, Sutapa (MS Candidate, B. Peyton)
1 M Bernstein, Hans (MS Candidate, R. Carlson)
4 F Biebel, Stacy (MS Candidate, A. Cunningham)
Sandvik, Elizabeth (MS Candidate, B. McLeod)
Wheeler, Laura (MS Candidate, A. Cunningham)

**PhD:** 8
Aston, John (PhD Candidate, B. Peyton)
5 M Chambless, Jason (PhD Candidate, P. Stewart)
3 F Davison, William (PhD Candidate, P. Stewart)
Fridjonsson, Einar (PhD Candidate, J. Seymour)
Hornemann, Jennifer (PhD Candidate, S. Codd)
Mallette, Natasha (PhD Candidate, R. Gerlach)
Van Engelen, Catherine (PhD Candidate, B. Peyton)
Van Engelen, Michael (PhD Candidate, B. Peyton)

**TOTALS**

<table>
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<th>Department</th>
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<td>Cell Biology &amp; Neuroscience</td>
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<td>Land Resources &amp; Environmental Sciences</td>
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<td>Molecular Bioscience</td>
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**TOTAL** 44 Total Grad:

15 total MS: 18 M / 8 F
15 total PhD: 26 M / 14 F

Total Male: 22
Total Female: 22

8: Civil / Environmental Engineering

**MS:** 4 Ba, Sidy (MS Candidate, W. Jones)
Schultz, Rickey (MS Candidate, O. Stein)
Taffs, Reed (MS Candidate, R. Carlson)
Trasky, Trevor (MS Candidate, W. Jones)

**PhD:** 4 Grabinski, Kevin (PhD Candidate, A. Camper)
3 M Jennings, Laura (PhD Candidate, A. Cunningham)
1 F Klayman, Benjamin (PhD Candidate, A. Camper)
Rahman, Mohammad Shahedur (PhD, A. Camper)

2: Computer Science

**MS:** 2 M Harmon, Rance (MS Candidate, R. Ross)
Aldrich, Steve (MS Candidate, R. Ross)

3: Land Resources & Environmental Sciences

**MS:** 1 F Taylor, Carrie (MS Candidate, O. Stein)
**PhD:** 2 Dieser, Markus (PhD Candidate, C. Foreman)
1 M Kirk, Lisa (PhD Candidate, B. Peyton)
1 F

2: Mechanical & Industrial Engineering

**MS:** 2 M Brindle, Eric (MS Candidate, P. Stewart)
Sutton, Michael (MS Candidate, B. Towler)

13: Microbiology

**MS:** 4 Behnke, Sabrina (MS Candidate, A. Camper)
1 M Coward, Kristin (MS Candidate, W. Jones)
3 F Pannier, Andy (MS Candidate, R. Gerlach)
Richard, Jessica (MS Candidate, M. Franklin)

**PhD:** 9 Brileya, Kristen (PhD Candidate, M. Fields)
2 M Clark, Melinda (PhD Candidate, M. Fields)
7 F Clark, Stewart (PhD Candidate, A. Camper)
Encarnacion, Gem (PhD Candidate, A. Camper)
Faulwetter, Jennifer (PhD Candidate, M. Burr)
Field, Erin (PhD Candidate, R. Gerlach)
Hwang, Chiachi (PhD Candidate, M. Fields)
Shirley, Storm (PhD Candidate, B. Peyton)
Sundararajan, Anitha (PhD Candidate, M. Fields)

2: Molecular Bioscience

**PhD:** 2 Bowen, Kara (PhD Candidate, M. Fields)
O’Shea, Kelly (PhD Candidate, M. Fields)
Graduating with advanced degrees, 2007–2008

**Sidy Ba**, MS, Environmental Engineering, Montana State University, May 2008: “Breakthrough of indicator organisms from slow sand filters as part of a drinking water production system for sub-Saharan Africa”

**Sutapa Barua**, MS, Chemical Engineering, Montana State University, June 2007: “Microbial diversity and zinc toxicity to Pseudomonas sp. from Coeur d’Alene river sediment”

**Jason D. Chambless**, PhD, Chemical and Biological Engineering, Montana State University, February 2008: “A 3D computer model investigation of biofilm detachment and protection mechanisms”

**William Marshall Davison**, PhD, Chemical and Biological Engineering, Montana State University, January 2008: “Spatial and temporal patterns of antimicrobial action against *Staphylococcus epidermidis* biofilms”

**Henriette Geier**, PhD, Microbiology, Montana State University, April 2008: “Environmental and genetic factors leading to *Mycobacterium avium* biofilm formation”

**Kevin Grabinski**, MS, Environmental Engineering, Montana State University, July 2007: “Pathogen transport and capture in a porous media biofilm reactor”

**Benjamin J. Klayman**, PhD, Environmental Engineering, Montana State University, June 2007: “A quantitative description at multiple scales of observation of accumulation and displacement patterns in single and dual-species biofilms”

**Jessica Richard**, MS, Microbiology, Montana State University, May 2008: “The two-component signal transduction systems of *Pseudomonas aeruginosa*”


**Mike Sutton**, MS, Environmental Engineering, Montana State University, March 2008: “Quantifying the viscoelastic properties of treated and untreated *Pseudomonas aeruginosa* and *Staphylococcus epidermidis* biofilms using a rheological creep analysis”
2007–2008 Student Awards and Honors

Amber Broadbent, PhD candidate in chemical and biological engineering, won the Conference Poster Award for “Quantifying velocity and mass transfer in Taylor-Couette flow” at the 9th International Conference on Magnetic Resonance Microscopy, in Aachen, Germany, September 3–7, 2007. She competed against 125 other poster presentations.

Melinda Clark, PhD candidate in microbiology, won second place in the poster competition for “Structural role for flagella in biofilm formation and stability in Desulfovibrio vulgaris Hildenborough” at the 2007 Environmental Subsurface Science Symposium, Utah State University, Logan, UT, July 25, 2007.

Markus Dieser, PhD candidate in land resources and environmental sciences, won Best Student Poster Presentation and an award of $250 for “Microbial diversity and the role of bacterial pigments as Cryo- or UV-protectants in Pony Lake, Antarctica” at the Society of International Limnology Meeting in Montreal, August 12–18, 2007. Authors were Markus Dieser and Christine Foreman.

Jennifer Hornemann, PhD candidate in chemical and biological engineering, won the February 2008 TAC’s Best Poster Award for “Magnetic resonance microscopy diffusion study of biofilm EPS.” Industrial attendees voted on the posters presented at the CBE’s open house and poster session.

Chiachi Hwang, PhD candidate in microbiology, won third place in the poster completion for “Changes in microbial community structure during biostimulation for uranium reduction” at the 2007 Environmental Subsurface Science Symposium, Utah State University, Logan, UT, July 25, 2007.

Laura Jennings, PhD candidate in environmental engineering, was awarded the 2008 Characklis Award. The award was presented to Laura at the CBE’s winter Technical Advisory Conference by Nancy Characklis. The W.G. Characklis Award was created in honor of the center’s founder and is presented to a CBE PhD student based on his or her contributions in research, education, outreach, and industrial interaction. Laura regularly organized outreach activities for K-12 students, has been one of the CBE seminar series organizers, and has team-taught the University Studies Course UNIV 125CS “Microbes in the Environment” course (taught by CBE-PhD students to non-science or -engineering undergraduate students). Her research work elucidates oxidative DCE transformation processes by combining microarray, proteomics, and chromatography-mass spectrometry techniques.

Tiffany Ready, undergraduate in microbiology, was awarded the R.G. Martin Award. This award is given every three years; the student receiving this award is selected by a committee of faculty members of the Department of Microbiology. Students are selected based on their overall classroom performance, their initiative in seeking opportunities to make original contributions to the field, and their efforts to disseminate accurate information about the field. This scholarship has been made available through the generosity Richard G. Martin.

2007–2008 Scholarships and Fellowships

Natasha Mallette, Reed Taffs and John Aston, PhD candidates in chemical and biological engineering, were recipients of a two-year Integrative Graduate Education and Research Training (IGERT) Fellowship in August 2007. This fellowship is awarded to those interested in focusing on the geomicrobiology of complex microbiological systems and bringing together expertise in hydrodynamics, geochemistry, microbial ecology, biochemistry, and genomics.

Melissa Schroeder, undergraduate in land resources and environmental sciences, was awarded the Erskine Excellence in Agriculture Scholarship and the Margaret Gina Sachs Memorial Scholarship.

Daniel Swanson, undergraduate in microbiology, was awarded the E.R. Dodge Scholarship.
Trevor Trasky, graduate student in environment engineering, was awarded the Mary & Robert Sanks Graduate Fellowship.

Carrie Taylor, master’s candidate in land resources and environmental sciences, was named a Big Sky Institute Science and Society Fellow for 2007–2008. The award is funded by the National Science Foundation Graduate Teaching Fellows in K12 Education (GK12) program. Carrie's application was chosen on the basis of a strong research record and extensive experience in communicating research to diverse groups of people. She received a stipend of $30,000 for one year, with an additional $10,500 cost-of-education allowance to offset tuition and fees, books, and supplies. Carrie is conducting research on constructed wetlands with her mentors Otto Stein, Paul Hook, and Cathy Zabinski.
<table>
<thead>
<tr>
<th>Date</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>29 Aug 2007</td>
<td>First week of classes</td>
<td>No seminar</td>
</tr>
<tr>
<td>06 Sep 2007</td>
<td>Dr. Dave Ward, MSU Professor, Land Resources and Environmental Sciences</td>
<td>Genomic and metagenomic analysis of a hot spring microbial mat community</td>
</tr>
<tr>
<td>13 Sep 2007</td>
<td>Dr. Sarah Codd, CBE Assistant Professor, Mechanical and Industrial Engineering</td>
<td>Biopolymer and water dynamics in microbial biofilm extracellular polymeric substance</td>
</tr>
<tr>
<td>20 Sep 2007</td>
<td>Dr. Garth James, CBE Research Scientist</td>
<td>Medical biofilm laboratory (MBL) summary</td>
</tr>
<tr>
<td>27 Sep 2007</td>
<td>Robert S. Maier, U.S. Army Engineering Research and Development Center Vicksburg, Mississippi</td>
<td>Modeling NMR experiments with pore-scale simulation</td>
</tr>
<tr>
<td>04 Oct 2007</td>
<td>Dr. Mike Semmens, Professor of Civil Engineering, University of Minnesota</td>
<td>Biofilm cohesiveness measurement using a novel atomic force microscopy methodology</td>
</tr>
<tr>
<td>11 Oct 2007</td>
<td>Melinda Clark, PhD Candidate, Microbiology</td>
<td>The physiological state of <em>Desulfovibrio vulgaris</em> biofilms</td>
</tr>
<tr>
<td>18 Oct 2007</td>
<td>Dr. James Folsom, CBE Postdoctoral Research Assistant</td>
<td><em>Listeria monocytogenes</em> biofilms: Strain variation and chlorine resistance</td>
</tr>
<tr>
<td>25 Oct 2007</td>
<td>Dr. Carrie Harwood, Professor of Microbiology, University of Washington</td>
<td>The role of oxygen and c-di-GMP on biofilm formation by <em>Pseudomonas aeruginosa</em></td>
</tr>
<tr>
<td>01 Nov 2007</td>
<td>Dr. Joe (Jizhong) Zhou, Presidential Professor, Department of Botany and Microbiology; Director, Institute for Environmental Genomics (IEG), University of Oklahoma</td>
<td>Microbial functional genomics, genomics technologies and environmental applications</td>
</tr>
<tr>
<td>08 Nov 2007</td>
<td>Dr. Andy Mitchell, CBE Assistant Research Professor</td>
<td>Requirement for outer-membrane c-type cytochromes for anaerobic growth of <em>Shewanella oneidensis</em> MR-1 on hematite</td>
</tr>
<tr>
<td>Date</td>
<td>Speaker</td>
<td>Topic</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>15 Nov 2007</td>
<td>Dr. Tony Romeo</td>
<td>Dispensing the glue: Identification and regulation of a biofilm adhesion</td>
</tr>
<tr>
<td>22 Nov 2007</td>
<td>Thanksgiving</td>
<td>No seminar</td>
</tr>
<tr>
<td>29 Nov 2007</td>
<td>No seminar</td>
<td>No seminar</td>
</tr>
<tr>
<td>06 Dec 2007</td>
<td>Last week of classes</td>
<td>No seminar</td>
</tr>
</tbody>
</table>
## 2008 CBE Spring Seminar Series

<table>
<thead>
<tr>
<th>Date</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 Jan 2008</td>
<td>Phil Stewart, Director and Paul Sturman, Coordinator of Industrial Development</td>
<td>Pre-TAC Talk</td>
</tr>
<tr>
<td>24 Jan 2008</td>
<td>No Seminar</td>
<td>No Seminar</td>
</tr>
<tr>
<td>31 Jan 2008</td>
<td>Dr. Sergio Morales Postdoctoral Research Assistant, University of Montana, Missoula</td>
<td>Validation of current 16S based phylogenetic analysis of complex bacterial communities</td>
</tr>
<tr>
<td>07 Feb 2008</td>
<td>Technical Advisory Conference (TAC)</td>
<td>TAC</td>
</tr>
<tr>
<td>14 Feb 2008</td>
<td>Laura K. Jennings PhD Candidate, Civil and Environmental Engineering, Cornell University</td>
<td>Proteomic, transcriptomic, and metabolomic analyses of cis-Dichloroethene degradation in <em>Polaromonas</em> sp. JS666</td>
</tr>
<tr>
<td>21 Feb 2008</td>
<td>Dr. Robin Gerlach MSU Associate Professor, Chemical and Biological Engineering Department</td>
<td>Bioremediation, bioenergy, carbon sequestration, and mass spectrometry - How does all this fit into the CBE?</td>
</tr>
<tr>
<td>28 Feb 2008</td>
<td>Dr. Luis Actis Professor and Chair Department of Microbiology, Miami University</td>
<td><em>Acinetobacter baumannii</em>. A sticky blood-smelling human pathogen</td>
</tr>
<tr>
<td>06 Mar 2008</td>
<td>Dr. Isaac Klapper Professor, Mathematical Sciences Department, MSU</td>
<td>Modeling material aspects of biofilms</td>
</tr>
<tr>
<td>13 Mar 2008</td>
<td>Spring Break</td>
<td>No Seminar</td>
</tr>
<tr>
<td>20 Mar 2008</td>
<td>University Holiday</td>
<td>No Seminar</td>
</tr>
<tr>
<td>27 Mar 2008</td>
<td>Dr. Marc Edwards MacArthur Fellow, 2007, Charles P. Lunsford Professor of Civil and Environmental Engineering, Virginia Tech</td>
<td>The research challenge of premise plumbing</td>
</tr>
<tr>
<td>03 Apr 2008</td>
<td>No Seminar</td>
<td>No Seminar</td>
</tr>
<tr>
<td>Date</td>
<td>Speaker</td>
<td>Topic</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------</td>
<td>-----------------------------------------------------------------------</td>
</tr>
<tr>
<td>10 Apr 2008</td>
<td>Dr. Ross Carlson</td>
<td>Limitations of quorum sensing interference and biofilm control in <em>Escherichia coli</em></td>
</tr>
<tr>
<td>17 Apr 2008</td>
<td>Dr. Mark Burr</td>
<td>Microbial community studies in constructed wetlands, biofilm reactors, and soils</td>
</tr>
<tr>
<td>25 Apr 2008</td>
<td>Dr. Chuck Gerba</td>
<td>Quantitative microbial risk assessment: Gambling with germs</td>
</tr>
<tr>
<td>01 May 2008</td>
<td>Last week of classes</td>
<td>No Seminar</td>
</tr>
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</table>
UNIV 125: Microbes in the Environment  Fall 2007

Class Meeting: Tuesdays and Thursdays 2:10-3:25; EPS 323

Instructors: Willy Davison  Jennifer Faulwetter  Erin Field
            Laura Jennings  Mike VanEngelen

Course Coordinator: Al Cunningham

Office Hours: Wednesdays 9:30-10:30am; 335 EPS or 338 EPS (Mike only)

Course Description
During the semester, students will explore contemporary issues related to microorganisms in the environment through a series of lectures and hands-on activities. Topics will include microbes in the environmental, industrial, and medical settings. Examples include the beneficial role microbes play in treating waste water, making beer, wine, cheese and other food products as well as problems caused by microbes in medical infections, hot tubs, drinking water, and other industrial systems. Completing this course will advance a student's awareness and appreciation of scientific thought, critical thinking and improve communication skills.

Course Goals
At the end of the course, students should be able to:
• Orally communicate ideas clearly and effectively
• Write a scientific-style research paper
• Give a scientific-style presentation
• Understand the role microbes play in natural and industrial processes
• Understand the role microbes play in human disease
• Read and interpret popular science articles

Evaluation

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
<th>Typical Curve:</th>
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</thead>
<tbody>
<tr>
<td>Exams – 35%</td>
<td></td>
<td>97-100 A+</td>
</tr>
<tr>
<td>Quiz 1 – 5%</td>
<td></td>
<td>93-97 A</td>
</tr>
<tr>
<td>Quiz 2 – 7.5%</td>
<td></td>
<td>90-93 A</td>
</tr>
<tr>
<td>Quiz 3 – 7.5%</td>
<td></td>
<td>87-89 B+</td>
</tr>
<tr>
<td>Final Exam – 15%</td>
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<td>83-87 B</td>
</tr>
<tr>
<td>Written Assignments– 30%</td>
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<td>80-83 B-</td>
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<tr>
<td>Module 1 – 10%</td>
<td></td>
<td>77-79 C+</td>
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<tr>
<td>Module 2 – 10%</td>
<td></td>
<td>73-77C</td>
</tr>
<tr>
<td>Module 3 – 10%</td>
<td></td>
<td>70-73 C</td>
</tr>
<tr>
<td>Project – 25%</td>
<td></td>
<td>67-69 D+</td>
</tr>
<tr>
<td>Intro – 5%</td>
<td></td>
<td>63-67 D</td>
</tr>
<tr>
<td>Final Presentation – 10%</td>
<td></td>
<td>60-63 D</td>
</tr>
<tr>
<td>Final Paper – 10%</td>
<td></td>
<td>&lt;60 F</td>
</tr>
</tbody>
</table>

Note: Final curve will be based on overall class performance…
UNIV 125: Microbes in the Environment  

Class Participation – 10%

Extra Credit: Extra credit may be earned in order to raise a student’s grade a maximum of 2% (i.e., B+ to an A-). Extra credit may be earned a number of ways, including attending on-campus seminars, summarizing relevant news/journal articles; opportunities will be announced in class.

Estimated Topics, by date

Introduction
  Aug 28 – Milestones in Microbiology
  Aug 30 – Overview of Microbiology Applications
  Sep 4 – Cell Biology
  Sep 6 – Metabolism

Module I - Environmental
  Sep 11 – Microbial Ecology
  Sep 13 – Prokaryotic Diversity I
  Sep 18 – Prokaryotic Diversity II
  Sep 20 – Eukaryotic Diversity
  Sep 25 – Microbes in Extreme Environments
  Sep 27 – Biogeochemical Cycling
  Oct 2 – Drinking Water
  Oct 4 – Wastewater

Module II - Medical
  Oct 9 – 40-min in-class Environmental Exam……….Intro to Medical Micro
  Oct 11 – Symbiosis
  Oct 16 – Immunity
  Oct 18 – Sterilization, Disinfection & Antisepsis
  Oct 23 – Hand Washing Lab
  Oct 25 – Antibiotics
  Oct 30 – Microbial Control, cont’d
  Nov 1 – Dental Microbiology

Module III - Industrial
  Nov 6 – 40-min in-class Medical Micro Exam……….. Intro to Food Micro
  Nov 8 – Food Spoilage/Food Poisoning
  Nov 13 – Food Production/Fermentation
  Nov 15 – Dairy Microbiology
  Nov 20 – Overview of Industrially Relevant Microbial Processes
  Nov 27 – Beneficial Microbial Processes
  Nov 29 – Detrimental Microbial Processes

Dec 4 – Presentations
Dec 6 – Presentations

Dec 11 – FINAL EXAM 2:00-3:50PM
## Current Industrial Membership (June 1, 2007–May 31, 2008)

<table>
<thead>
<tr>
<th>ORGANIZATION</th>
<th>TYPE OF INDUSTRY</th>
<th>NUMBER OF YEARS OF SUPPORT</th>
</tr>
</thead>
<tbody>
<tr>
<td>3M</td>
<td>Healthcare</td>
<td>07,08</td>
</tr>
<tr>
<td>Bausch &amp; Lomb</td>
<td>Healthcare</td>
<td>07,08</td>
</tr>
<tr>
<td>Bridge Preclinical Testing Services</td>
<td>Testing Laboratory</td>
<td>07,08</td>
</tr>
<tr>
<td>Cardinal Health (formerly enturia, Inc.)</td>
<td>Healthcare</td>
<td>07,08</td>
</tr>
<tr>
<td>Church &amp; Dwight Co., Inc.</td>
<td>Household Products</td>
<td>02,03,04,05,06,07,08</td>
</tr>
<tr>
<td>Ciba Specialty Chemicals</td>
<td>Specialty Chemicals</td>
<td>07,08</td>
</tr>
<tr>
<td>Colgate-Palmolive</td>
<td>Household Products</td>
<td>00,01,02,03,04,05,06,07,08</td>
</tr>
<tr>
<td>ConvaTec</td>
<td>Healthcare</td>
<td>07,08</td>
</tr>
<tr>
<td>Covidien (formerly Tyco Healthcare)</td>
<td>Healthcare</td>
<td>98,99,00,01,02,03,04,05,06,07,08</td>
</tr>
<tr>
<td>Cubist*</td>
<td>Pharmaceutical</td>
<td>08</td>
</tr>
<tr>
<td>The Dow Chemical Company</td>
<td>Specialty Chemicals</td>
<td>90,91,92,93,94,95,98,99,00,01,02,03,04,05,06,07,08</td>
</tr>
<tr>
<td>Ecolab, Inc.</td>
<td>Specialty Chemicals</td>
<td>05,06,07,08</td>
</tr>
<tr>
<td>Embro Corporation</td>
<td>Testing Laboratory</td>
<td>07,08</td>
</tr>
<tr>
<td>Ethox International*</td>
<td>Testing Laboratory</td>
<td>08</td>
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<tr>
<td>Glanbia Nutritionals*</td>
<td>Healthcare</td>
<td>08</td>
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<tr>
<td>GlaxoSmithKline</td>
<td>Pharmaceutical</td>
<td>04,05,06,07,08</td>
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<tr>
<td>Kimberly-Clark*</td>
<td>Healthcare</td>
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<tr>
<td>Masco Corporation</td>
<td>Household Products</td>
<td>05,06,07,08</td>
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<tr>
<td>Mölnlycke Health Care</td>
<td>Healthcare</td>
<td>07,08</td>
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<tr>
<td>NASA</td>
<td>Government Lab</td>
<td>05,06,07,08</td>
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<tr>
<td>NovaBay Pharmaceuticals, Inc.</td>
<td>Pharmaceutical</td>
<td>05,06,07,08</td>
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<tr>
<td>Novozymes A/S</td>
<td>Healthcare</td>
<td>05,06,07,08</td>
</tr>
<tr>
<td>Procter &amp; Gamble Company</td>
<td>Household Products</td>
<td>07,08</td>
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<tr>
<td>QuoNova LLC*</td>
<td>Pharmaceutical</td>
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<tr>
<td>Reckitt Benckiser</td>
<td>Household Products</td>
<td>07,08</td>
</tr>
<tr>
<td>Rohm and Haas*</td>
<td>Specialty Chemicals</td>
<td>08</td>
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<tr>
<td>Sandia National Laboratories</td>
<td>National Laboratory</td>
<td>07,08</td>
</tr>
<tr>
<td>Stryker Orthobiologics*</td>
<td>Healthcare</td>
<td>08</td>
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</table>
INDUSTRY : INDUSTRIAL ASSOCIATES

<table>
<thead>
<tr>
<th>ORGANIZATION</th>
<th>TYPE OF INDUSTRY</th>
<th>NUMBER OF YEARS OF SUPPORT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Targanta Therapeutics, Corp.*</td>
<td>Pharmaceutical</td>
<td>08</td>
</tr>
<tr>
<td>Unilever</td>
<td>Household Products</td>
<td>06,07,08</td>
</tr>
<tr>
<td>W.L. Gore &amp; Associates</td>
<td>Healthcare</td>
<td>97,98,99,00,01,02,03,04,05,06,07,08</td>
</tr>
<tr>
<td>Whirlpool Corporation</td>
<td>Household Products</td>
<td>06,07,08</td>
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</tbody>
</table>

*New members in 2007-2008

**New CBE Industrial Associates**

Cubist Pharmaceuticals is a biopharmaceutical company focused on developing and commercializing anti-infective therapies for the acute care environment.

Ethox International distributes more than 80 brand-name hospital products in almost every country in the world, and is the only contract service provider able to offer one source for medical and pharmaceutical needs worldwide.

Glanbia Nutritionals focuses on the expert delivery of science-based nutritional solutions. With production facilities located in Idaho, New Mexico, and Ireland, Glanbia delivers a wide range of specialty whey protein isolates, whey protein concentrates, whey fractions, milk proteins, dairy calcium and other nutritional ingredients.

For 135 years Kimberly-Clark has provided consumers worldwide with solutions that improve their health, hygiene, and well-being. It is a global company, employing over 55,000 people.

Based in Melbourne, Florida, QuoNova was established in December 2006 with the aim of developing a proprietary quorum sensing blocker (QSB) technology for commercialization. In August 2007 QuoNova Europe GmbH was established in Munich to support the company’s global efforts in exploitation of the technology platform, with special focus on human healthcare applications.

Rohm and Haas has been delivering on innovation since 1909 by pairing creativity with sound knowledge, making it possible for companies to meet ever-changing market demands. More than 16,500 Rohm and Haas professionals develop specialty and performance materials for customers in more than 100 facilities with operations in 27 countries.

Stryker Orthobiologics has invested over 20 years of clinical research in developing a wide range of biological technologies that hold the promise of regeneration and healing for patients suffering from bone, cartilage and soft tissue injuries and defects. Stryker offers biomaterials and regenerative biological products for clinical specialties including trauma, spine, craniomaxillofacial and joint replacement.

Targanta Therapeutics Corporation is a biopharmaceutical company focused on the development and commercialization of innovative antibiotics to treat serious infections in the hospital and other institutional settings.
Monday
July 23

6:00–9:30 p.m.
Pre-registration and welcome reception
Hilton Garden Inn, Bozeman

Tuesday
July 24

7:30–8:30 a.m.
Registration and continental breakfast
Hilton Garden Inn reception area
8:30–8:45
Introductory remarks
Larkspur Ballroom
Paul Sturman, CBE Industrial Coordinator
Ruth Cutright, W.L. Gore, TAC Chair
Phil Stewart, CBE Director

SESSION 1: Wound Biofilms

8:45–8:50
Session introduction
Garth James, Medical Projects Manager, CBE

8:50–9:15
Biology of wound healing
John Olerud, MD, Professor of Dermatology, University of Washington

9:15–9:45
Advances in wound microbiology
Philip Bowler, Director, Anti-Infectives & Microbiology, Wound Therapeutics Global Development Centre, ConvaTec, Flintshire, UK

9:45–10:00
Overview of the Center for Wound Biofilm Research
Phil Stewart

10:00–10:30 Break

10:30–10:50
In vitro models of wound biofilms
Garth James

10:50–11:10
Preclinical modeling:
Studies on wound healing
Stephen Davis, Research Associate Professor of Dermatology, University of Miami, Miller School of Medicine

11:10–11:30
Biofilm models in acute wounds
Patricia Mertz, Professor of Dermatology, University of Miami, Miller School of Medicine

11:30–12:00
Biofilm based wound care
Randy Wolcott, MD, Southwest Regional Wound Care Center

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

SESSION 2: Special Presentations

1:00–1:30
State of the CBE: 2007
Phil Stewart

1:30–2:00
Regulatory presentation:
An update on federal activities
Stephen Tomasino, Senior Scientist, US EPA-OPP Microbiology Laboratory, Fort Meade, Maryland

2:00–2:30
Caserna, nanowires, signal vesicles and flying buttresses:
Baroque architecture in biofilms
Bill Costerton, Director, Center for Biofilms, School of Dentistry, University of Southern California

2:30–2:50 Break

2:50–3:20
Biocide industry: Past, present and future challenges for biocontrol
Michael V. Enzien, Senior Research & Development Specialist, DOW Biocides, The Dow Chemical Company

SESSION 3: Biofilm Behavior and Control

3:20–3:40
Examination of scCO2 effects against Bacillus mojavensis biofilms
Adie Phillips, Research Engineer, CBE

3:40–4:00
Influence of EPS and natural organic matter on biofouling of microfiltration membranes coupled with powdered activated carbon (PAC)
Mohiuddin Md. Taimur Khan, Assistant Research Professor, CBE

4:00–4:20
Investigations of dormant cells in Pseudomonas aeruginosa biofilms
Brenda Grau, Postdoctoral Researcher, CBE

SESSION 4: Biofilm Methods

4:20–4:45
Methods of assessing efficacy of antimicrobial surfaces: A review
Diane K. Walker, Research Engineer, CBE

4:45–5:10
Transcriptomes and proteomes: Identification of physiological constraints related to biofilm growth
Matthew Fields, Assistant Professor, Microbiology, Montana State University

7:30–9:00
Evening Session:
Biofilm Methods Advisory Committee
**Wednesday**

**July 25**

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

**Special Presentation**  
8:30–9:30  
Predatory prokaryotes: Thinking outside the bug  
Daniel Kadouri, Assistant Professor, Department of Oral Biology & the Center for Oral Infectious Diseases, University of Medicine and Dentistry of New Jersey, Newark

**SESSION 5:**  
Biofilms in Water Venues

9:30–9:40  
Session introduction  
Darla Goeres, Senior Research Engineer, CBE

9:40–10:10  
Disease outbreaks in recreational water  
Michael J. Beach, Acting Associate Director for Healthy Water, National Center for Zoonotic, Vector-Borne and Enteric Diseases, Centers for Disease Control and Prevention

10:10–10:40 Break

10:40–11:10  
Drinking water issues in developing countries  
Tim Ford, Department Head, Microbiology, Montana State University

11:10–11:35  
Drinking water treatment strategies and regulations  
Anne Camper, Professor of Civil Engineering, CBE

11:35–12:00  
Understanding the importance of biofilm in recreational water  
Darla Goeres

Lunch: On your own

2:00–4:00  
Laboratory open house exposition and poster session  
CBE Laboratories, 3rd Floor, EPS Building

**Thursday**

**July 26**

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

**SESSION 6:**  
Microscopy

8:30–8:45  
Session introduction & new stains  
Betsey Pitts, Research Associate, CBE

8:45–9:05  
Examination of tissue specimens for biofilms  
Alessandra Agostinho, Research Scientist, CBE

9:05–9:25  
Use of laser capture microdissection microscopy and qRT-PCR to characterize gene expression in biofilms  
Ailyn Lenz, PhD Candidate, Microbiology, Montana State University

9:25–9:45  
Extended lifetime of unstable GFP in *Escherichia coli* colony biofilm  
Audrey Corbin, Research Associate, CBE

9:45–10:05  
Film Fest: Movies of biofilm obliteration, annihilation, doom and destruction  
Willy Davison, PhD Candidate, Chemical Engineering, Montana State University

10:05–10:30 Break

**SESSION 7:**  
Fungal Biofilms

10:30–10:55  
Functional subpopulations in *Candida albicans* biofilms  
Peter Suci, Assistant Research Professor, Plant Sciences, Montana State University

10:55–11:20  
Small novel molecules inhibit signaling pathways and hyphal formation in *Candida albicans*  
Kurt Toenjes, Assistant Professor, Department of Biological and Physical Sciences, MSU–Billings

**Special Presentation**

11:20–11:50  
Highlights from the ASM Biofilms 2007 Conference  
Phil Stewart

11:50–12:00  
Meeting Wrap-Up

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**NEXT TAC:**  
Feb. 7-8, 2008
Biofilm Methods Workshop

Basics Option

July 23, 2007

9:00 – 9:45  Welcome, Introductions – Paul Sturman, EPS 323
Using Scanning Electron Microscopy (SEM) to Study Biofilm –
Matthew Fields, EPS 323

9:45 – 10:30  Standardized Biofilm Methods – Darla Goeres, Marty Hamilton, Standardize a
research method for routine use; Experimental design; Statistics. EPS 323

10:30 – 10:45  Coffee Break/Discussion

10:45 – 12:00  Biofilm Growth Reactors – Diane Walker, Kelli Buckingham-Meyer, Lindsey
Lorenz, SBM Interns EPS 337

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

1:15 - 2:30  Biofilm Reactor Protocol: Set-up, Inoculation, Sampling and Analysis –
Diane Walker, Kelli Buckingham-Meyer, Lindsey Lorenz, SBM Interns EPS 337

2:30 – 3:30  Cryosectioning and Microscopy of Biofilms – Betsey Pitts, Alessandra
Agostinho EPS 326/327


4:15 – 5:00  Wrap-up/Discussion and Selected CBE Presentations:
Adie Phillips – “Supercritical CO₂ Challenges.” EPS 302

Shannon Goeres – Bioresources Engineering Undergraduate, “Fun with Pipes.”
EPS 301

Wrap-Up, Discussion – Paul Sturman, EPS 323
Biofilm Methods Workshop

Advanced Option

July 23, 2007

9:00 – 9:45 Welcome, Introductions – Paul Sturman, EPS 323
Using Scanning Electron Microscopy (SEM) to Study Biofilm – Matthew Fields, EPS 323

9:45 – 11:00 A Fractionation Method for Assessing Differential Gene Expression in Colony Biofilms – Brenda Grau, EPS 312

11:00 – 11:15 Coffee Break/Discussion

11:15 – 12:00 Cryosectioning and Microscopy – Alessandra Agostinho and Betsey Pitts EPS 326

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

1:15 - 2:15 A Laser Dissection Method for Assessing Differential Gene Expression in Biofilms/ Tour of MicroArray Facility – Mike Franklin, Kate McInerney, Cooley Lab

2:15 – 3:00 SEM Imaging of CDC Reactor Biofilms – Steve Fisher ICAL, EPS 339

3:00 – 3:30 Mass Spectrometry at the CBE – Robin Gerlach, EPS 329

3:30 – 4:15 Image Analysis – Betsey Pitts, EPS 317

4:15 – 5:00 Selected CBE Presentations:
Adie Phillips – “Supercritical CO₂ Challenges” EPS 302
Shannon Goeres – Bioresources Engineering Undergraduate, “Fun with Pipes” EPS 301

Wrap-Up, Discussion – Paul Sturman, EPS 323
Tuesday
February 5
6:00–9:00 p.m.
Pre-registration and
welcome reception
Hilton Garden Inn, Bozeman

Wednesday
February 6
7:30–8:30 a.m.
Registration and
continental breakfast
Hilton Garden Inn reception area

8:30–8:45
Introductory remarks
Larkspur Ballroom
Paul Sturman, CBE Industrial
Coordinator
Ruth Cutright, W.L. Gore,
TAC Chair
Phil Stewart, CBE Director

Keynote Presentation
8:45–9:30
Biofilm dispersal: Molecular
mechanisms to control strategies
Jeremy Webb, School of Biological
Sciences, University of
Southampton, UK

SESSION 1: Industrial Biofilm
Investigations
9:30–9:35
Session Introduction
Paul Sturman

9:35–10:10
Overview of biofilm detachment
mechanisms
Brent Peyton, Professor,
Chemical & Biological
Engineering, CBE

10:10–10:40 Break

10:40–11:05
Biofilms in bioenergy and carbon
sequestration
Robin Gerlach, Associate Professor,
Chemical & Biological
Engineering, CBE

11:05–11:30
Biocontrol studies at Novozymes
Biologicals
Sarah McHatton, Novozymes

11:30–12:00
Transcriptomics and molecular
techniques for biofilm
investigation in industrial systems
Matthew Fields, Assistant Professor,
Microbiology, CBE

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

SESSION 2: Visualizing Biofilms
1:00–1:10
Session Introduction
Phil Stewart

1:10–1:35
A quantitative description at
multiple scales of observation of
accumulation and displacement
patterns in single- and dual-
species biofilms
Anne Camper, Professor, Civil
Engineering, CBE

1:35–2:00
Recent advances in cellular
automata modeling of
multispecies biofilm systems
Al Cunningham, Professor, Civil
Engineering, CBE

2:00–2:30
Fluorescence hyperspectral
imaging of biofilms
Howland Jones, Sandia National
Laboratories

2:30–3:00
Direct visualization of
antimicrobial action within
model oral biofilms
Phil Stewart

Poster Session
& Laboratory Open House
3:30–5:30
CBE Laboratories, 3rd Floor EPS
Building, MSU

Dinner: Restaurant of your choice

7:30–9:00 Hilton Garden Inn
Evening Session:
Biofilms Methods Advisory
Committee Meeting
Basic Biofilm Methods Workshop

Feb 5, 2008

9:00 – 9:30  Welcome & Introductions – Paul Sturman EPS 323

9:30 – 10:30  Biofilm Growth Reactors & Demo – Diane Walker, Kelli Buckingham-Meyer, Lindsey Lorenz, Jackie Hilyard, Shannon Goeres, Alex Hilyard EPS 337

10:30 – 11:00  Morning Refreshments

11:00 – 12:00  Biofilm Reactor Protocol: Hands-on Sampling and Analysis – Diane Walker, Kelli Buckingham-Meyer, Lindsey Lorenz, Jackie Hilyard, Shannon Goeres, Alex Hilyard EPS 337

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

1:15 - 2:00  Standardizing a Research Method for Routine Use – Darla Goeres, Marty Hamilton EPS 323

2:00 – 2:30  Staining Biofilms – Diane Gray* EPS 323

Group A:

2:30 – 3:15  Microscopy of Biofilms – Betsey Pitts, Diane Gray, Willy Davison, Liz Sandvik, Kelly Kirker, Pat Secor, Alessandra Agostinho EPS 326/327


3:15 – 3:30  Afternoon Refreshments

Group B:


3:30 – 4:15  Microscopy of Biofilms – Betsey Pitts, Diane Gray, Willy Davison, Liz Sandvik, Kelly Kirker, Pat Secor, Alessandra Agostinho EPS 326/327

4:15 – 5:00  Lab Show & Tell:
  - Treatment of Biofilms Using Direct Current – Liz Sandvik EPS 302
  - Reduction of Hexavalent Chromium by Desulfovibrio vulgaris Biofilms Under Steady State Conditions – Melinda Clark EPS 336

Wrap-Up/Discussion – Paul Sturman EPS 323

*Special guest instructor from Molecular Probes/Invitrogen
Visiting Researchers, CBE 2007–2008

Diana Amari—a graduate student from CBE PhD alumnus David Davies’ lab in Binghamton, NY—joined Anne Camper’s drinking water research group for the summer of 2007. Diana worked with Pat Secor, Lynne Leach, and Andreas Nocker on a project that examines differences in 2D protein patterns between organisms grown in a single-species biofilm and grown in multi-species biofilms.

Dr. Virginia Anderson of Towson State University, Maryland—a collaborator on the CBE’s NSF-sponsored Biofilms: The Hypertextbook project (grant numbers 0089397 and 0618744)—visited the CBE during the first week of November. Dr. Anderson, whose specialty is educational assessment and evaluation, attended one session of a class that has been using the Hypertextbook prototype and worked with local grant team members Rocky Ross, Al Cunningham, and Diane Williams to produce materials and instruments for ongoing teaching and learning evaluation of the Hypertextbook.

Sonia Porta Banderas, research scholar from Valencia, Spain, worked in the Biofilm Control lab from October through December 2007. Sonia works for Ainia Centro Tecnologico in Valencia, where she is a microbiological technician. She came to the CBE to learn biofilm methods related to food microbiology and was funded by a grant from the Spanish government.

Eliora Bujari, an undergraduate student in environmental engineering from Manhattan College in New York, joined visiting faculty Chris Groth to work on a project investigating the effects of biofilm formation on porous media hydrodynamics during the summer of 2007.

Abdoulaye Camara, visiting from Bamako, Mali, worked in CBE labs from June 2006 to September 2007. He collaborated with Mark Burr, Andreas Nocker, Lynne Leach, and Jennifer Faulwetter in the Industrial and Environmental Water Systems lab headed by Anne Camper.

Gregory Characklis, associate professor of environmental engineering from the University of North Carolina–Chapel Hill, was a visiting faculty member at the CBE during the summer of 2007. He conducts research in the area of pathogen transport in storm water runoff systems. He brought four of his students for several days to present their research and to explore the Center’s research and education programs. As the son of the Center’s founding director W.G. (Bill) and Nancy Characklis, Greg has historical ties to the Center.

Chris Groth, a master’s candidate in environmental engineering from Manhattan College in New York, visited the Center during the summer of 2007. Chris set up model porous media reactors to continue CBE studies on the effect of biofilm formation on porous media hydrodynamics. He worked with Robin Gerlach, chemical and biological engineering, and Al Cunningham, civil engineering. Chris’ work at Manhattan College is under the supervision of Robert Sharp (a CBE PhD graduate in 1995).

Kim Harris, a researcher at Procter & Gamble in Egham, UK, came to the CBE to work with Betsey Pitts on biofilm microscopy and to talk with other CBE researchers about biofilm growth and imaging techniques.

John Lennox, professor emeritus, microbiology, Penn State Altoona, came to the CBE for the month of April in 2008 to work on biofilm education projects. As a co-editor, John is committed to bringing the biofilm concept into the undergraduate science and engineering curriculum and he contributed to the success of the Biofilms: The Hypertextbook project (grant numbers 0089397 and 0618744). During this visit, John collaborated with Rocky Ross and Al Cunningham on the hypertextbook project and also prepared material to present at the American Society for Microbiology Undergraduate Conference, May 31–June 1, 2008.

Hung Nguyen, a graduate student from Washington State University, Pullman WA, worked with Zbigniew Lewandowski and Haluk Beyenal, assistant professor of chemical engineering and bioengineering, WSU, Pullman. Together, the three put on a week-long biofilms summer school in the summer of 2007.
Susana Sánchez, a PhD candidate in microbiology from the University of Navarra, Spain, worked in the Biofilm Control lab from May 1 to September 30, 2007. With her expertise in peptides, Susana evaluated the ability of antimicrobial peptides—a natural class of antimicrobial agents—to control biofilm formation by the opportunistic pathogen Pseudomonas aeruginosa.

Priscilla Sossa, a PhD candidate in microbiology from the University of Antofagasta, Chile, returned to the CBE for a research visit in 2007.

Lourdes Jiménez Taracido, a graduate student from the University of Cádiz in Spain studying marine consortia and biofilms, worked with the CBE’s Biofilm Control lab and with Ross Carlson’s lab for the three months during the summer of 2007. Lourdes developed an AI2 quorum sensing reporter system for E. coli.
2007 Initiative: Interdisciplinary Research Retreat
Biofilm Mechanics Workshop

June 28-30, 2007
Montana State University Campus
Bozeman, Montana

A workshop review, by Phil Stewart

Early summer can be a beautiful time in Montana, and so it was at the end of June 2007 when the Center for Biofilm Engineering (CBE) hosted a workshop on the topic of biofilm mechanics on the Montana State University campus. This event brought together twenty-six participants from Montana, Texas, Florida, New York, Minnesota, Pennsylvania, North Carolina, Canada, Germany, and the Netherlands to share ideas and recent results about what holds microbial biofilms together and how these biological assemblages can be understood as mechanical structures that deform, move, and flow. The meeting was informal, convivial, and collaborative in spirit. Technical presentations were interspersed with discussion sessions. The modest size of the group and relaxed atmosphere helped make the questioning and discussion particularly unfettered, creative, and leavened with humor. The group dined together in the cellar of an attractive restaurant in historic downtown Bozeman, and a free afternoon allowed for some fishing, hiking, beer sipping, and project planning. We are indebted to Isaac Klapper for conceiving this event and organizing the program.

The interdisciplinary nature of the group was obvious at lunch one day when our table of five included a physicist, a chemical engineer, two microbiologists, and an electrical engineer. Also represented among the workshop participants were mathematicians, civil engineers, mechanical engineers, a biomedical engineer and a biochemist.

Rather than encapsulate specific talks, let me just summarize here some of the themes, hypotheses, and ideas that emerged in the course of the workshop:

- Biofilm cohesion is realized through multiple polymers and multiple cohesive forces.
- Specific polysaccharides are distributed heterogeneously in the biofilm matrix; these can be localized via lectin staining and microscopy.
- Abiotic components (precipitates, corrosion products, dead white blood cells, etc.) are significant in real-world systems and likely contribute to the material properties of biofilms.
- Biofilm should not be a prison; biological pathways for dispersion of cells from a biofilm are being elucidated.
- Biofilm properties are being probed and forces measured by pushing and pulling on biofilms with ingenious instrumental adaptations of atomic force microscopes, micropipette cantilevers, magnetic resonance microscopes, and fluid jets.
- These measurements point to microscale heterogeneity in the distribution of EPS and in local mechanical properties.
- Fluid-biofilm interactions give rise to drag, lift, detachment, channeling, differential effects during antimicrobial treatment, and also to complex motions of the biomass such as oscillation, mixing, and rolling.
- Cells compete for space and displace their neighbors as bacteria grow inside a biofilm.
Modelers are tackling biofilm mechanics by simulating a network of interconnected, breakable springs or by describing the biofilm as a compressible fluid subjected to combined attractive and repellant forces.

One of my visions for the CBE is that this center will serve as a meeting ground where researchers can come together to brainstorm and network for mutual benefit. I would like to thank all of the Biofilm Mechanics Workshop participants for helping to make this an example of this spirit of sharing and synthesis. I am inspired by the success of this event to seek ways to continue regular workshops of this kind.

Participant List

Recep Avci, Physics, MSU, Bozeman, MT
Bruce Ayati, Mathematics, Southern Methodist University, Dallas, TX
Sarah Codd, Mechanical & Industrial Engineering & CBE, MSU, Bozeman, MT
Nick Cogan, Mathematics, Florida State University, Tallahassee, FL
Al Cunningham, Civil Engineering & CBE, MSU, Bozeman, MT
David G. Davies, Biological Sciences, Binghamton University, Binghamton, NY
Willy Davison, Chemical & Biological Engineering & CBE, MSU, Bozeman, MT
Jack Dockery, Mathematical Science & CBE, MSU, Bozeman, MT
John Dutcher, Physics, University of Guelph, Guelph, ON, Canada
Hans-Curt Flemming, Biofilm Centre, University of Duisburg-Essen, Duisburg, Germany
Michael Franklin, Microbiology & CBE, MSU, Bozeman, MT
Gill Geesey, Microbiology & CBE, MSU, Bozeman, MT
Robin Gerlach, Chemical & Biological Engineering & CBE, MSU, Bozeman, MT
Raymond M. Hozalski, Civil Engineering, University of Minnesota, Minneapolis, MN
Jennifer Hornemann, Chemical & Biological Engineering & CBE, MSU, Bozeman, MT
Isaac Klapper, Mathematical Science & CBE, MSU, Bozeman, MT
Ben Klayman, Civil & Environmental Engineering & CBE, MSU, Bozeman, MT
Bertram Manz, Magnetic Resonance Imaging, Fraunhofer-Institut für Biomedizinische Technik, St. Ingbert Germany
Thomas R. Neu, Helmholtz Centre for Environmental Research, Magdeburg, Germany
Ekaterina Paramonova, Biomedical Engineering, University Medical Center Groningen and University of Groningen, Groningen, The Netherlands
Joseph Seymour, Chemical & Biological Engineering & CBE, MSU, Bozeman, MT
Phil Stewart, Chemical & Biological Engineering & CBE, MSU, Bozeman, MT
Paul Stoodley, Center for Genomic Sciences, Allegheny-Singer Research Institute, Pittsburgh PA
Zhiyong Suo, Physics, Montana State University, Bozeman, MT
Michael Sutton, Center for Biofilm Engineering & CBE, MSU, Bozeman, MT
Ahmed Touhami, Physics, University of Guelph, Guelph, ON, Canada
Daniel Wozniak, Microbiology & Immunology, Wake Forest University School of Medicine, Winston-Salem, NC
Image Use Requests

Web requests for educational use of CBE images were received from 18 countries outside the US:

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- Belgium
- Brazil
- Canada
- Denmark
- England
- France
- Germany
- Greece
- India
- Ireland
- Mexico
- The Netherlands
- Poland
- Slovenia
- South Africa
- Taiwan
- United Kingdom

Web requests for educational use of CBE images were received from 33 of the United States:

- California
- Colorado
- Florida
- Georgia
- Idaho
- Iowa
- Kentucky
- Illinois
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- Missouri
- Montana
- Nebraska
- Nevada
- New Jersey
- New York
- North Carolina
- Ohio
- Oklahoma
- Oregon
- Pennsylvania
- South Carolina
- South Dakota
- Tennessee
- Texas
- Utah
- Vermont
- Virginia
- Washington
- West Virginia
- Wisconsin
2008 CBE Program and Facilities

Center for Biofilm Engineering Program Overview

Montana State University’s Center for Biofilm Engineering (CBE) offers an ideal setting for the interdisciplinary, collaborative research that is the basis for its worldwide reputation in the field of biofilms. Graduate and undergraduate students work under the guidance of the CBE’s multidisciplinary faculty in contiguous laboratories to solve problems associated with biofilms in industry, medicine, and the environment. The CBE’s standing in the international research community attracts visiting students and faculty from all parts of the world, providing a culturally diverse and stimulating academic environment.

Established in 1990 with a grant from the National Science Foundation, the CBE became a member of the elite Engineering Research Centers program. The NSF-ERC program was created to increase U.S. industrial competitiveness and to re-invent science and engineering education in U.S. universities. In order to promote achievement of the ERC program goals, the NSF-ERC program called for the contribution of significant support from ERC universities and industrial partners. The Center for Biofilm Engineering drew support from the State of Montana, Montana State University–Bozeman, and the industrial partners gathered during its pre-1990 work as the Institute for Process Analysis. After its 11-year period of NSF-ERC grant support drew to a close, the CBE built on the foundation of its many years of successful government-university-industry collaboration in pursuit of its vision as a world leader in fundamental research, science and engineering education, industrially relevant technology, and the synthesis of biofilm-related information.

The mission of the Center for Biofilm Engineering is to advance the basic knowledge, technology and education required to understand, control, and utilize biofilm processes.

The CBE has identified goals in four areas of activity. In the area of research, the CBE’s goal is to do leading edge fundamental research to elucidate the mechanisms at work in bacterial biofilms. The CBE has been a leader in defining the structure and function of biofilms on surfaces, in understanding the antimicrobial resistance mechanisms of biofilm, and in identifying the role of signal molecules in controlling bacterial behavior. To the naked eye, biofilms simply look like slimy matter, but researchers at the CBE have demonstrated that they are actually multicellular attached communities, with primitive circulatory systems and a measure of cellular specialization. Understanding these fundamental biofilm characteristics and activities presents opportunities for developing more effective strategies to control biofilms in industrial settings. The second goal of the CBE is to make its research relevant to real systems, where the information can be useful. Industrial partnerships help to keep the ultimate focus of CBE research on real-world applications. Technology transfer at the CBE involves not only information, but methods and technology development. The CBE even has a laboratory specifically designated to develop these methods—the Standardized Biofilm Methods laboratory (SBM). The CBE’s third goal is to sustain productive interdisciplinary undergraduate and graduate education programs involving team research on industrially relevant projects. Education is at the heart of the CBE’s success. Undergraduates and graduate students are fully integrated into the development, design and implementation of research projects at the CBE, spanning a wide range of biofilm topics and applications. Hundreds of students from a dozen MSU departments have contributed to CBE research over the years. Many have graduated to take positions in industry and academia, continuing to be active and influential in the biofilm field. The most recent goal of the CBE is to provide educational outreach. The CBE’s outreach efforts include workshops, symposiums, training, Internet resources, and a new initiative to produce an electronic, interactive ‘hypertextbook’ on biofilms to supplement undergraduate science and engineering education.

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 ft² facility includes: offices and conference rooms for faculty, staff, and students; two computer laboratories; and thirteen state-of-the-art research laboratories. The 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 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, new, 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 new 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. So, for imaging thick or dense biofilms, the MaiTai is the perfect tool.

- 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 twelve state-of-the-art PCs along with scanning and printing services. In addition, the CBE 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 μm in a sample space up to 6 cm diameter.
MSU ICAL Laboratory

The Image and Chemical Analysis Laboratory (ICAL) in the Physics Department at Montana State University is located on the 3rd floor of the EPS Building, adjacent to the Center for Biofilm Engineering. ICAL MSU was established in order to promote interdisciplinary collaboration in research, education, and industry, and to strengthen existing cooperation between the physical, biological, and engineering sciences by providing critically needed analytical facilities. These facilities are open to academic researchers.

A new critical point dryer—jointly purchased in 2007 by the CBE and the Image & Chemical Analysis Laboratory—has been set up in the ICAL lab for the processing of biological samples for electron microscopy. This equipment allows our researchers to remove water from soft samples without distorting the sample.

The ICAL currently contains seven complementary microanalytical systems:

- Atomic Force Microscope (AFM)
- Auger Scanning Electron Microprobe (Auger)
- Field Emission Scanning Electron Microscope (FESEM)
- Scanning Electron Microscope (SEM)
- Time of Flight Secondary Ion Mass Spectrometer (SIMS)
- Small-Spot X-ray Photoelectron Spectrometer (XPS)
- X-Ray Powder Diffraction Spectrometer (XRD)

For more information on each system, see the ICAL web site at: http://www.physics.montana.edu/ICAL/ICAL.html.