

**2008  
annual  
report**



**making**

# **CONNECTIONS**

**in biofilm research**

**center for biofilm**

**engineering**

**montana state university**



# director's message phil stewart



Thirty-five years ago I was a shy science nerd at Newton Middle School in California. One day a group of us took a field trip into the city to take a lesson from a business professor. We interacted in a role-playing game in which we were each assigned to run a different business. I do not recall the details of the game. I do remember the professor's evaluation when the game was over: "You all get a big fat 'F'." Exercising our American instinct to compete, we had withheld our resources for fear that someone else would get ahead. The lesson we learned was that if we had looked for ways to share, trade, and partner, all of our businesses could have prospered. Working together, we could all have been "winners."

Cooperation and collaboration have been effective strategies for us at the Center for Biofilm Engineering for many years now, and this spirit is as alive as ever. In a culture that spotlights the individual and inculcates competition, we need occasional reminders to continue working as teams and trusting in the payoff of freely sharing ideas and expertise. So I would like to take this opportunity to reaffirm, for those of us here at the CBE, and also for our constituents and colleagues elsewhere, my commitment to promoting an environment of partnership.

Here are some examples of how the CBE engages in and facilitates partnerships:

- For the five-year period from 2003–2008, our co-authors on published technical articles hailed from 39 different academic institutions, 7 national laboratories, 4 federal agencies, and 12 private companies.
- During the past year, 64 companies provided funding to the CBE in the form of sponsored research projects and/or as members of our Industrial Associates program.
- For the five-year period from 2003–2008, invited seminar speakers at the CBE represented 50 different academic institutions or companies.
- Our formal collaborators currently include individuals from 17 institutions spanning North America.
- In the past three years, the CBE has hosted visitors from Brazil, Chile, France, Germany, Ireland, Japan, Korea, Mali, Russia, Spain, Switzerland, and numerous states.

This year's annual report highlights the CBE's connectivity in the biofilm world and gives us a chance to tip our hats to colleagues and collaborators around the globe.

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*See page 16 for information about the cover photos. Thanks to Betsey Pitts for the confocal scanning laser microscope biofilm images on the front cover and to numerous CBE students and staff who took the photographs in this report.*

Please see the **2008 Appendix** for more information about CBE activity during the past year, including details about the major current research collaborations highlighted in yellow boxes throughout this report. We value these collaborations with key researchers at other institutions in the US and Canada.

### RESEARCH COLLABORATION

*Ray Hozalski,  
University of  
Minnesota,  
Minneapolis, MN  
(Stewart & Camper)*





steady river of new research grants totaling just over \$4.0 million flowed into the CBE in the past year. Once again the funding comes from diverse sources including the Department of Energy, Environmental Protection Agency, National Institutes of Health, National Science Foundation, National Aeronautics and Space Administration, the State of Montana, and the Idaho National Laboratory. The projects span such varied topics as the development of antimicrobial testing methodologies, elucidation of microbial stress and survival in the environment, mechanics of bacterial biofilms, control of infections on knee implants, and metabolic engineering. In addition to these research contracts, forty-three private companies sponsored project work during the last year. Particularly in times of tough competition for governmental funding, these are encouraging indicators for research at the CBE.

### CBE associated faculty specialties

*See Appendix for more information*

- Microbial community analysis ■ Biofilms in environmental systems ■ Metabolic engineering ■ Metabolic networks ■ Magnetic resonance imaging ■ Subsurface biotechnology and bioremediation ■ Physiology and ecology ■ Mathematical models of biofilms ■ Microbial ecology in cold temperature environments ■ Drinking water ■ Public health microbiology ■ Molecular genetics, gene expression ■ Molecular and cellular interactions at interfaces ■ Environmental biotechnology and bioremediation ■ Standardized biofilm methods ■ Applied biostatistics ■ Fluorescent proteins and genetically encoded biosensors ■ Medical biofilms ■ Water distribution systems ■ Environmental engineering ■ Microsensors, chemical gradients, biofilm structure ■ Organic synthesis, signaling analogues ■ Biofilms in extreme environments ■ Bioelectric effect ■ Experimental mechanics ■ Geomicrobiology ■ Food microbiology ■ Web-based, active learning education ■ Engineered waste remediation ■ Biofilm control strategies ■ Fungal biofilms

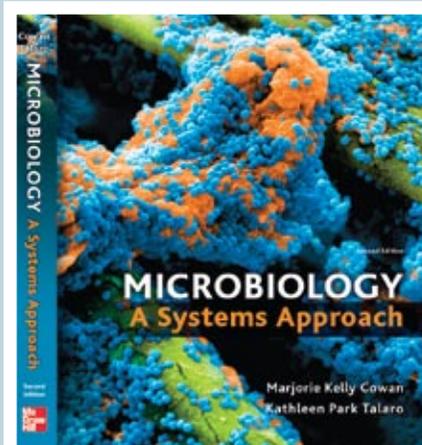
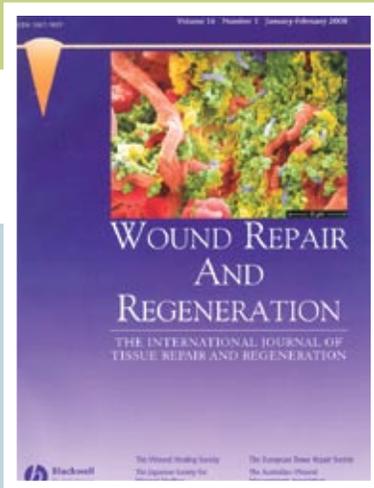
# RESEARCH

Research area	Activities
Bioelectrochemistry	Microbially influenced corrosion, microbial fuel cells
Biofilm Control/Antimicrobials	Biofilm resistance mechanisms, effective use of antimicrobials, alternative control strategies
Bioremediation	Degradation, removal, or containment of contaminants in soil and groundwater
Industrial & Environmental Water Systems	Role of biofilms in water quality, corrosion, and use of biological pretreatment to improve water quality
Medical Biofilms	Role of biofilms in disease
Physiology & Ecology	Physiological activities of organisms and interactions between species
Standardized Biofilm Methods	Development and dissemination of standardized methods for biofilm testing
Structure-Function	Relationship between biofilm structure, transport processes, rheology, and biological activity

*Research areas supported by the CBE are summarized in the table above. This list encompasses those areas in which the CBE has current, significant, and sustained activity.*

## 4 research

### recent covers



Cover images used with permission

### ISI Web of Science report: CBE leads the pack of cited MSU papers

Results of a recent search for the **most cited papers** from **Montana State University** are summarized below. They indicate that the CBE has made significant long-term contributions to MSU's reputation for quality research.

For the time period 1998–2008, **6 of the top 10 most cited MSU papers were generated by CBE authors**; 13 of the top 50 were CBE papers.

**CBE papers ranked #1** (most frequently cited) of all MSU papers published in **1998, 1999, 2001, 2002, 2003, 2004, and 2005.**

(Search conducted 03/28/2008)

#### *Journal of Bacteriology*

189(11): 4223-4233, June 2007

**Cover image:** Suriani Abdul Rani, Peg Dirckx  
**Article:**

Rani SA, Pitts B, Beyenal H, Veluchamy RA, Lewandowski Z, Davison WM, Buckingham-Meyer K, and Stewart PS; "Spatial patterns of DNA replication, protein synthesis and oxygen concentration within bacterial biofilms reveal diverse physiological states."

### **Nature Reviews | Microbiology** Featured article

**"Physiological heterogeneity in biofilms"**

**Stewart PS and Franklin MJ**

*Nat Rev Microbiol*, **6(3):199-210 (2008)**

CBE director Phil Stewart and microbiology professor Michael Franklin co-authored the March 2008 featured article in *Nature Reviews | Microbiology*, which discusses the processes that generate chemical gradients in biofilms, genetic and physiological responses of bacteria, and techniques for visualizing and measuring physiological heterogeneities of bacteria in biofilms.

## 33 papers 2007-08 PUBLICATIONS

#### *Wound Repair and Regeneration*

Vol 16, No 1: 37-44, Jan-Feb 2008

**Cover image:** Ellen Swogger, Peg Dirckx

**Article:**

James GA, Swogger E, Wolcott R, deLancey Pulcini E, Secor P, Sestrich J, Costerton JW, and Stewart PS; "Biofilms in chronic wounds."

#### **Science Brevia**

#### **Raining bugs and microbes?**

**"Ubiquity of biological ice nucleators in snowfall,"** Christner BC, Morris CE, Foreman CM, Cai R, Sands DC

*Science*, 319 (5867):1214 (2008)

CBE faculty member **Christine Foreman** contributed to this collaborative work with visiting researcher **Cindy Morris** (INRA, Avignon, France) and other researchers led by Dave Sands, MSU Plant Sciences and Plant Pathology. Their results indicate that the biosphere is a source of highly active ice nucleators and suggest that these biological particles may affect the precipitation cycle and/or their own precipitation during atmospheric transport.

#### *Microbiology: A Systems Approach*

2nd ed, by Marjorie Kelly Cowan and Kathleen Park Talero

ISBN10: 0077224779

ISBN13: 9780077224776

Published by McGraw-Hill Science/Engineering/Math, 2008.

Cover SEM microscopy by Ellen Swogger, during her undergraduate research at the CBE. Ellen worked in the Medical Biofilm Laboratory on chronic wound research. This image shows bacterial colonization of gauze fibers.

#### **RESEARCH COLLABORATION**

*Phil Fleckman, MD & John Olerud, MD, University of Washington, Seattle, WA*  
(Stewart & James)



Matthew Fields

**RESEARCH COLLABORATION**

Adam Arkin,  
Terry Hazen,  
Jay Keasling,  
Lawrence Berkeley  
National Laboratory,  
CA (Fields)

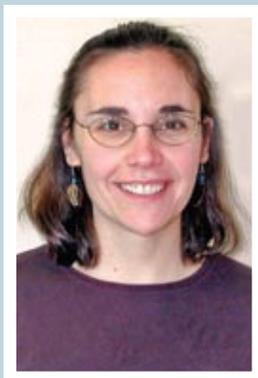
**DOE rewards multi-institutional collaboration**

In recognition of a very successful collaboration, the US Department of Energy granted a five-year renewal of the Virtual Institute for Microbial Stress and Survival: Environmental Stress Pathway Project (VIMSS:ESPP2), which emphasizes both high-throughput genetics and environmental studies. Three national laboratories combine with seven affiliated universities to comprise the new ESPP2. Under the leadership of Adam P. Arkin (UC-Berkeley, Lawrence Berkeley National Laboratory) and Terry C. Hazen (LBNL), co-investigators are all veterans of the original collaboration: Jay Keasling (UC, LBNL), Aindrila Mukhopadhyay (LBNL), **Matthew Fields** (Montana State University and CBE), Kelly Bender (University of Illinois at Chicago), Eric Alm (Massachusetts Institute of Technology), Judy Wall (University of Missouri-Columbia), David Stahl (University of Washington), Jizhong Zhou (Oklahoma University), Martin Keller (Oak Ridge National Laboratory) and Anup Singh (Sandia National Laboratories).

The project characterizes the molecular basis for stress responses in microbial community structure, function, and stability in laboratory and field-scale experiments. Microbial communities play key roles in some of the Department of Energy's main concerns in climate change, energy, and environmental remediation. The multi-institutional collaboration is a large-scale systems biology effort.

The award to Montana State University is \$1.65 million dollars over five years, a very significant grant for co-PI Matthew Fields and the Center for Biofilm Engineering. Matthew and his team will investigate the molecular and physiological basis for interactions between sulfate-, iron-, and carbon dioxide-reducing populations in biofilms and will characterize microbial communities from chromium and uranium contaminated sites in order to better understand their roles in heavy metal remediation.

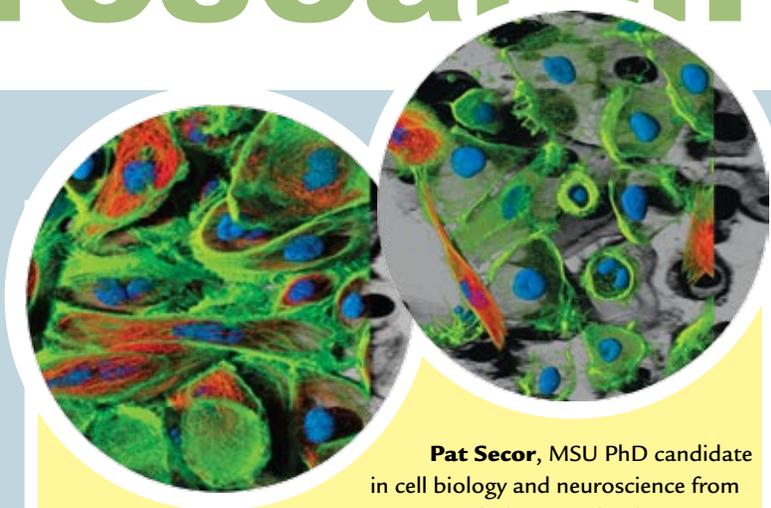
research



Darla Goeres

**EPA awards \$1.7 million for antimicrobial test methodology**

In April 2008, the **Standardized Biofilm Methods Laboratory** was awarded a five-year, \$1.7 million contract with the US Environmental Protection Agency (EPA) for laboratory research to support the development and standardization of test methods for measuring the performance of antimicrobial products, including those for biofilm bacteria; statistical services related to EPA's Office of Pesticide Programs Antimicrobial Testing Program; and various Homeland Security initiatives. **Darla Goeres** is the contract's principal investigator and **Marty Hamilton** of Big Sky Statistical Analysts, LLC, will collaborate on the project as a statistical subcontractor.



**Pat Secor**, MSU PhD candidate in cell biology and neuroscience from Bozeman, took these confocal scanning laser microscope (CSLM) images of human epidermal cells as part of his project "**Molecular analysis of chronic wound infections.**" The image on the left is of healthy cells; cells on the right have been in contact with *Staphylococcus aureus* biofilm. Pat observed that the biofilm induces morphological changes in epidermal cells. These changes directly reduce the ability of the epidermal cells to migrate and, therefore, to close wounds.



E. Brook

**New faculty**

**Abigail Richards** joined the Chemical and Biological Engineering Department of Montana State University's College of Engineering as an assistant professor. Richards' research interests include biofilm growth in extreme environments and microbial remediation of soils that have been contaminated by heavy metals or radionuclides. Richards earned her doctorate in chemical engineering from Washington State University in 2007. She conducted her doctoral research as a visiting student at the CBE.

## 6 education

### Undergraduate Student Summary

Discipline	Male	Female	TOTAL
Ag Biotechnology	1		1
Biomedical Science		1	1
Business	1		1
Cell Biology & Neuroscience	1	1	2
Chemical & Biological Engineering	11	5	16
Civil Engineering	3	3	6
Computer Science	1		1
Electrical & Computer Engineering	1		1
Land Resources & Env. Sci. (1-Bridges Prgm)	1	1	2
Microbiology	3	4	7
Nursing (Bridges Prgm)		1	1
<b>TOTAL</b>	<b>23</b>	<b>16</b>	<b>39</b>

*Liz Sandvik, master's candidate in chemical and biological engineering*



# EDUCATION



**Dan Horn**, center, with **Markus Dieser** and **Christine Foreman**, attended a leadership conference in Connecticut where he presented his poster "Growth characteristics of a bacterial isolate from Cotton Glacier, Antarctica." Dan, an undergraduate majoring in computer technology at Ft. Belknap College, helped Markus with the computer application GelComparII. He participated in the summer 2007 BRIDGES program, a partnership between MSU and five Montana tribal colleges directed by John Watts.

**Markus Dieser**, a PhD candidate in land resources and environmental sciences, won Best Student Poster Presentation at the Society of International Limnology Meeting in Montreal, August 2007, for his research at Pony Lake, Antarctica. Faculty advisor **Christine Foreman**, land resources and environmental sciences, is an expert on microbial ecology in cold temperature environments.



Continuing eighteen successful years of experience in multi-disciplinary interaction, CBE-affiliated **faculty members representing 11 MSU departments** led biofilm research efforts. Both undergraduate and graduate students benefit from the CBE educational experience, which includes industry-relevant research projects, regular interaction with industry representatives, a weekly seminar series, and opportunities to present their research to a variety of audiences.

#### UNDERGRADUATE STUDENTS

- **39** undergraduates from **11** disciplines participated in CBE research projects in the past school year.
- **41%** of the undergraduates were female.
- **84%** of the undergraduates were from Montana towns.

#### GRADUATE STUDENTS

- **44** graduate students from **8** departments were pursuing higher degrees.
- **18** were masters candidates; **26** were doctoral candidates.
- **50%** of the graduate students were female.
- **43%** of the graduate students come from Montana hometowns.

CBE students from other countries contribute their unique experiences and cultural backgrounds, enriching the educational environment; this year student home countries included **Austria, Bangladesh, Chile, Germany, Iceland, India, Mali, Nepal, the Philippines, South Africa, and Taiwan.**

For more information about the CBE education program, see the Web at [www.biofilm.montana.edu/CBEssentials-SW/education/](http://www.biofilm.montana.edu/CBEssentials-SW/education/)



Kevin Cook, assistant professor in mechanical and industrial engineering (M&IE), observes while undergraduate **Alex Hilyard** demonstrates sampling and treating methods with a CDC reactor as part of a collaborative project between the Standardized Biofilm Methods team and the M&IE department funded by the Montana Board of Research and Commercialization Technology. Cook's senior level class "Design for Manufacturing and Tooling" worked with the CBE and Bryan Warwood, Biosurface Technologies (Bozeman), to optimize a prototype of a rapid biofilm analysis kit.

# education

## IGERT offers new program for graduate students

**Natasha Mallette, Reed Taffs and John Aston**, PhD candidates in chemical and biological engineering, were recipients of two-year Integrative Graduate Education and Research Training (IGERT) fellowships in August 2007. The fellowship is awarded to students interested in focusing on the geomicrobiology of complex microbiological systems; it brings together expertise in hydrodynamics, geochemistry, microbial ecology, biochemistry, and genomics. The IGERT program meshes well with the CBE's interdisciplinary approach to microbial biofilms. In addition to her cold biology research, **Christine Foreman** (pictured on page 6) has recently taken a half-time position as Assistant Director for IGERT. Among other responsibilities, she will act as a liaison for students and for the public on relevant issues.



Graduate Student Summary			
Discipline	MS/PhD	Male	Female
<b>1 Cell Biology &amp; Neuroscience</b>			
1	PhD	1	
<b>13 Chemical &amp; Biological Engineering</b>			
5	MS	1	4
8	PhD	5	3
<b>8 Civil / Environmental Engineering</b>			
4	MS	4	
4	PhD	3	1
<b>2 Computer Science</b>			
2	MS	2	
<b>3 Land Resources &amp; Environmental Sciences</b>			
1	MS		1
2	PhD	1	1
<b>2 Mechanical &amp; Industrial Engineering</b>			
2	MS	2	
<b>13 Microbiology</b>			
4	MS	1	3
9	PhD	2	7
<b>2 Molecular Bioscience</b>			
2	PhD		2
<b>TOTAL: 44</b>	<b>18 MS/ 26 PhD</b>	<b>M: 22</b>	<b>F: 22</b>

## RESEARCH COLLABORATION

*James Gossett, Cornell University, Ithaca, NY*



*At left, Nancy Characklis, who presents the award annually, with Laura Jennings.*

## Jennings receives CBE's Characklis Award

Laura Jennings is a Cornell University PhD candidate in environmental engineering who is completing her research at the CBE. With the cooperation of her Cornell advisor, James Gossett, the CBE has benefited from Laura's many contributions and her rigorous scholarship. The W.G. Characklis award was presented at the CBE's winter Technical Advisory Conference by Nancy Characklis. This award was created in honor of the center's founder and is presented to a CBE PhD student based on contributions in research, education, outreach, and industrial interaction. Laura's research elucidates oxidative contaminant transformation processes by combining microarrays, proteomics, and chromatography/mass spectrometry techniques.

# 8 Recent collaborations

## 2003–2008

The CBE makes it a point to interact meaningfully with top bio-film researchers across the United States and from other countries. These pages show a snapshot of researcher interactions during the past five years. Numbers/row colors indicate the nature of the collaboration:

<b>1: Co-author on a peer-reviewed paper</b>
<b>2: CBE seminar or conference speaker</b>
<b>3: Both 1 &amp; 2—co-author and speaker</b>
<b>4: Recent formal collaborator on a grant</b>

### RESEARCH COLLABORATION

Tracy Bank,  
University of  
Buffalo, NY  
(Fields)

### US REGION: SOUTH ATLANTIC

NAME	INSTITUTION	ST
2: N Cogan	Florida State Univ, Tallahassee	FL
2: S Davis	Univ of Miami, Miami	FL
2: R Lamont	Univ of Florida, Gainesville	FL
1: J Lisle	USGS, St. Petersburg	FL
2: P Mertz	Univ of Miami	FL
2: M Beach	CDC, Atlanta	GA
3: R Donlan	CDC, Atlanta	GA
1: D Kirby	CDC, Atlanta	GA
1: R Murga	CDC, Atlanta	GA
2: T Romeo	Emory Univ, Atlanta	GA
2: M Doyle	Univ of Georgia, Griffin	GA
4: V Anderson	Towson State Univ	MD
3: M Shirliff	Univ of Maryland, Baltimore	MD
3: S Tomasino	EPA, Ft. Meade	MD
2: M Rindal	EPA, Ft. Meade	MD
2: D Hill	Univ of N Carolina, Chapel Hill	NC
2: D Wozniak	Wake Forest Univ, School of Medicine, Winston-Salem	NC
2: A Neal	Savannah River Ecology, Aiken	SC
1: D Ohman	Virginia Commonwealth Univ, Richmond	VA
4: A Dietrich	Virginia Polytechnic, Blacksburg	VA
4: M Edwards	Virginia Polytechnic, Blacksburg	VA

### US REGION: NORTHEAST

NAME	INSTITUTION	ST
4: E Alm	MIT, Cambridge	MA
1: N Balaban	Tufts Univ, North Grafton	MA
2: K Lewis	Northeastern Univ, Boston	MA
1: G O'Toole	Dartmouth Univ, Hanover	NH
2: B Bassler	Princeton Univ	NJ
4: M Celia	Princeton Univ	NJ
2: D Kadouri	Univ of Medicine & Dentistry of New Jersey, Newark	NJ
2: D Davies	Binghamton Univ	NY
2: A Rickard	Binghamton Univ	NY
2: K Sauer	Binghamton Univ	NY
4: J Gossett	Cornell Univ, Ithaca	NY
4: T Bank	Univ of Buffalo	NY
2: B Iglewski	Univ of Rochester	NY
3: R Sharp	Manhattan College, Riverside	NY
3: G Ehrlich	Allegheny-Singer Research Institute, Pittsburgh	PA
1: L Hall-Stoodley	Allegheny-Singer Research Institute, Pittsburgh	PA
3: P Stoodley	Allegheny-Singer Research Institute, Pittsburgh	PA
4: J Lennox	Penn State Altoona	PA

### US REGION: SOUTH CENTRAL

NAME	INSTITUTION	ST
2: D Worley	Auburn Univ, Auburn	AL
3: B Little	Naval Research Lab, Stennis Space Center	MS
4: Z He	Oklahoma State Univ, Norman	OK
1: M Patrauchan	Oklahoma State Univ, Norman	OK
4: J Zhou	Oklahoma State Univ, Norman	OK
4: P Jardine	Oak Ridge National Lab	TN
4: R Wolcott	Southwest Regional Wound Care Center, Lubbock	TX
3: T Wood	Texas A&M Univ, College Station	TX
2: J Fralick	Texas Tech Univ, Lubbock	TX
2: S Chellam	Univ of Houston	TX
1: S Dowd	USDA, Lubbock	TX

### RESEARCH COLLABORATION

Marc Edwards, Virginia Polytechnic, Blacksburg, VA  
(Camper)

## RESEARCH COLLABORATION

William Apel & Brady Lee, Idaho National Laboratory, Idaho Falls, ID (Gerlach & Peyton)  
 Brady Lee & Frank Roberto, INL (Carlson)

### US REGION: MIDWEST

NAME	INSTITUTION	ST
2: K Kemner	Argonne National Lab	IL
4: L Hanley	Univ of Illinois, Chicago	IL
1: D Nivens	Purdue Univ, W. Lafayette	IN
1: B Ayati	Univ of Iowa, Iowa City	IA
1: A Horswill	Univ of Iowa, Iowa City	IA
4: R Hozalski	Univ of Minnesota, Minneapolis	MN
2: R Patel	Mayo Clinic, Rochester	MN
2: M Semmens	Univ of Minnesota, Minneapolis	MN
1: D Webb	Bemidji State Univ, Bemidji	MN
1: M Mormile	Missouri Univ of Science, Rolla	MO
4: J Wall	Univ of Missouri, Columbia	MO
1: M Ghannoum	Univ Hospital Cleveland	OH
2: D Hassett	Univ of Cincinnati	OH
2: V Brozel	SD State Univ, Brookings	SD
1: R Sani	SD School of Mines, Rapid City	SD
2: A Wong	Univ of Wisconsin, Madison	WI

### US REGION: PACIFIC WEST

NAME	INSTITUTION	ST
2: J Leadbetter	CalTech, Pasadena	CA
4: A Arkin	Lawrence Berkeley Natl Lab	CA
4: T Hazen	Lawrence Berkeley Natl Lab	CA
4: J Keasling	Lawrence Berkeley Natl Lab	CA
1: T Ginn	Univ of California-Davis	CA
3: B Costerton	Univ of S California, Los Angeles	CA
2: M Dolan	Oregon State Univ, Corvallis	OR
4: C Reimers	Oregon State Univ, Corvallis	OR
1: J Amonette	Pacific NW Natl Lab, Richland	WA
2: Y Gorby	Pacific NW Natl Lab, Richland	WA
2: J McLean	Pacific NW Natl Lab, Richland	WA
1: A Willse	Pacific NW Natl Lab, Richland	WA
2: J Berg	Univ of Washington, Seattle	WA
4: P Fleckman	Univ of Washington, Seattle	WA
2: P Greenberg	Univ of Washington, Seattle	WA
2: C Harwood	Univ of Washington, Seattle	WA
2: P Mourad	Univ of Washington, Seattle	WA
4: J Olerud	Univ of Washington, Seattle	WA
3: M Parsek	Univ of Washington, Seattle	WA
4: B Ratner	Univ of Washington, Seattle	WA
2: P Singh	Univ of Washington, Seattle	WA
4: D Stahl	Univ of Washington, Seattle	WA
4: D Stolar	Univ of Washington, Seattle	WA
4: H Beyenal	Wash State Univ, Pullman	WA
1: J Petersen	Wash State Univ, Pullman	WA
1: F Caccavo	Whitworth College, Spokane	WA

### INTERNATIONAL

NAME	INSTITUTION	COUNTRY
1: S Kjelleberg	Univ of New South Wales, Sydney	Australia
3: M Desrosiers	Univ of Montreal, Quebec	Canada
1: D Miller	Univ of British Columbia, Vancouver	Canada
4: A Nantel	McGill Univ, Montreal, Quebec	Canada
2: K Sossa	Univ of Concepción	Chile
3: M Givskov	Danish Technical Univ, Lyngby	Denmark
1: S Molin	Danish Technical Univ, Lyngby	Denmark
2: P Nielsen	Univ of Aalborg	Denmark
2: C Dorel	INSA, Lyon	France
3: C Morris	INRA, Avignon	France
2: D de Beer	Max Planck Institute, Bremen	Germany
2: H-C Flemming	Univ of Duisburg-Essen	Germany
4: R Helmig	Univ of Stuttgart	Germany
2: W Uhl	Univ of Duisburg-Essen	Germany
1: G Donelli	Univ La Sapienza, Rome	Italy
3: S Takenaka	Univ of Niigata	Japan
1: C Picioreanu	Delft Univ of Technology	The Netherlands
1: M van Loosdrecht	Delft Univ of Technology	The Netherlands
1: R Naumova	Kazan State Univ, Kazan	Russia
1: A Ziganshin	Kazan State Univ, Kazan	Russia
2: K Yeon	Seoul National Univ	South Korea
3: J Yoon	Seoul National Univ	South Korea
3: C Fux	Univ of Bern	Switzerland
2: V Caner	Pamukkale Univ, Denizli	Turkey
3: P Gilbert	Univ of Manchester	United Kingdom
2: J Webb	Univ of Southampton	United Kingdom

### US REGION: MOUNTAIN WEST

NAME	INSTITUTION	ST
2: C Gerba	Univ of Arizona, Tucson	AZ
3: J Leid	Northern Arizona Univ, Flagstaff	AZ
1: T Borch	Colorado State Univ, Fort Collins	CO
4: W Apel	Idaho National Lab, Idaho Falls	ID
4: S Billingsley	Inland Northwest Research Alliance	ID
2: R Crawford	Univ of Idaho, Moscow	ID
2: M Otto	Rocky Mountain Lab, Hamilton	MT
2: K Toenjes	Montana State Univ, Billings	MT
1: K Hollis	Los Alamos National Lab	NM
1: J Kaszuba	Los Alamos National Lab	NM
2: H Jones	Sandia National Labs, Albuquerque	NM
1: W Pitt	Brigham Young Univ, Provo	UT
2: P Savage	Brigham Young Univ, Provo	UT
4: R Sims	Utah State Univ, Logan	UT
1: S Viamajala	Utah State Univ, Logan	UT
1 B Tyler	Univ of Utah, Salt Lake City	UT



The CBE added **8 new members** in 2007–2008, bringing our Industrial Associates program to **32 member companies**, a record high. This growth was due to continued strong interest among companies concerned with improved healing (Stryker Orthobiologics), personal care products (Kimberly-Clark, Rohm and Haas, Glanbia), biopharmaceuticals (Cubist, Targanta Therapeutics, QuoNova), as well as testing and service companies (Ethox).

A rapidly growing area of our program continues to be the **small business membership**, which now includes 6 members. This program provides a mechanism for companies fitting the US government definition of a small business to participate in the CBE Industrial Associates program alongside some of the largest players in the market.



*Poster sessions in the CBE hallways and laboratories have proven to be popular with Technical Advisory Conference attendees and students. Above, undergraduate Andrea Hartman and below, graduate student Jennifer Hornemann explain their research to industrial visitors.*

# INDUSTRY

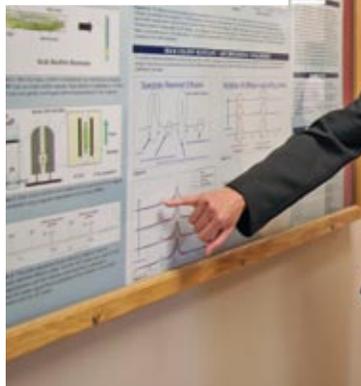
The **Biofilm Methods Advisory Committee (BMAC)** has become a cornerstone of our industrial program, bringing together regulators from the US EPA and FDA with CBE members interested in the development of sound methods to assess product performance with regard to biofilms. The BMAC meets at each Technical Advisory Conference and features interactive discussion of current issues, such as the adoption of a standard method to assess the performance of liquid microbicides. This method is currently under consideration by ASTM, and input by members of the advisory committee has been essential to its development.

*Pictured above, Standardized Biofilm Methods team members Diane Walker, Darla Goeres, and Marty Hamilton meet with Steven Tomasino, EPA, at the summer 2007 Technical Advisory Conference in Bozeman.*



## RESEARCH COLLABORATION

Luke Hanley,  
University of  
Illinois, Chicago, IL  
(Carlson)



**RESEARCH  
COLLABORATION**

Phil Jardine,  
Oak Ridge National Laboratory, TN  
(Fields)

# industry

## An open invitation

The CBE is supported in part by Industrial Associate annual subscriptions as well as company sponsorship of research and testing projects. Twice each year, the CBE holds Technical Advisory Conferences (TAC) to showcase research done in our labs and in biofilm labs around the world. Attendance at a TAC is open to representatives from member companies, as well as those interested in finding out more about our industrial program. If you are interested in attending, please contact Paul Sturman (paul\_s@biofilm.montana.edu) for more information.



Staff member Lindsey Lorenz provided instruction about biofilm methods to industry representatives at a recent workshop held in association with the CBE Technical Advisory Conference.

## Second biofilm ASTM standard adopted

Biofilm is the subject of a new ASTM International standard: E 2562, Test Method for Quantification of *Pseudomonas aeruginosa* Biofilm Grown with High Shear and Continuous Flow Using CDC Biofilm Reactor. The new standard is under the jurisdiction of Subcommittee E35.15 on Antimicrobial Agents, which is part of ASTM International Committee E35 on Pesticides and Alternative Control Agents.

E 2562 is one of only two standards that address how to grow, sample, and analyze biofilm bacteria. The other standard, also developed with CBE efforts, is ASTM International document: E 2196, Test Method for Quantification of a *Pseudomonas aeruginosa* Biofilm Grown with Shear and Continuous Flow Using a Rotating Disk Reactor.

Interested parties are invited to join the standards developing activities of Subcommittee E35.15, which will eventually include proposed low shear and no shear biofilm growth protocols and treatment protocols. Darla Goeres leads the CBE initiative in the standardization of biofilm methods.

## CBE Industrial Associates

3M

Bausch & Lomb

Bridge Preclinical Testing Services

Cardinal Health (formerly enturia, Inc.)

Church & Dwight Co., Inc.

Ciba Specialty Chemicals

Colgate-Palmolive

ConvaTec

Covidien (formerly Tyco Healthcare)

Cubist \*

The Dow Chemical Company

Ecolab

Embryo Corporation

Ethox International \*

Glanbia Nutritionals \*

GlaxoSmithKline

Kimberly-Clark\*

Masco Corporation

Mölnlycke Health Care

NASA

NovaBay Pharmaceuticals, Inc.

Novozymes A/S

Procter & Gamble Company

QuoNova, LLC \*

Reckitt Benckiser

Rohm and Haas\*

Sandia National Laboratories

Stryker Orthobiologics\*

Targanta Therapeutics, Corp.\*

Unilever

W.L. Gore & Associates

Whirlpool Corporation

\* new members in 2007–2008

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Each TAC includes a business meeting of Industrial Associate members to provide input for CBE planning and to coordinate collaborative efforts.

## MSU licenses the Propidium Monoazide (PMA) Live/Dead Analysis to Qiagen

Qiagen—a worldwide leading provider of sample and assay technologies for life sciences, applied testing, and molecular diagnostics—has licensed MSU’s new method for distinguishing between live and dead bacteria in molecular assays.

The method could potentially be used in microbial diagnostics to selectively detect the live portion of a broad range of bacteria when screening for disease-causing microorganisms in food and water, clinical diagnostics, bioterrorism assays, evaluating disinfection efficacy, and testing the sterility of drugs and personal care products. Prior to molecular analysis, the samples are treated with propidium monoazide and exposed to bright visible light. This process binds the chemical only to the DNA of dead cells so the dead cells are blocked from being read by the assay; thus, only live cells are detected. The method can be performed in about 10 minutes without any specialized expertise.



**Andreas Nocker**, above, and **Anne Camper**, below, were the inventors of the new method. Andreas established initial contact with Qiagen and worked with the MSU Technology Transfer Office on the licensing.

### BEYOND FUNDING, 2003–2008: OTHER INDUSTRY CONTRIBUTIONS

- 1: Co-author on peer-reviewed publications
- 2: CBE invited seminar speaker
- 3: CBE invited Technical Advisory Conference speaker

NAME	COMPANY	PL
1: J Geiger, T Palys, B Sandel	Arch Chemicals, Norwalk	CT
1: G Dell’Acqua	BalaPharm International, Grafton	MA
1: H Rossmoore	Biosan Laboratories, Warren	MI
1: W Dickinson	Buckman Laboratories, Memphis	TN
2: D McIlwaine	ChemTreat, Ashland	VA
3: M Czechowski	Church & Dwight, Princeton	NJ
3: D Cummins	Colgate-Palmolive, Piscataway	NJ
1: H Trivedi	Colgate-Palmolive, Piscataway	NJ
3: P Bowler	ConvaTec, Flintshire	UK
3: T Morris	Cumbre, Dallas	TX
3: G Maale	Dallas Ft. Worth Sarcoma Group	TX
3: M Enzien	Dow, Buffalo Grove	IL
1: L Bedzyk	DuPont, Wilmington	DE
3: M Dorsey	DuPont, Orange	TX
3: S Burnett	Ecolab, Eagan	MN
3: M Fornalik	Kodak, Rochester	NY
3: B Cali	Microbia, Inc., Cambridge	MA
1: J Combie	Montana Biotech, Belgrade	MT
2: S Wallace	NA Wetland Eng, Forest Lake	MN
3: S McHatton	Novozymes A/S, Salem	VA
3: C McInnes	Philips Oral Healthcare, Snoqualmie	WA
1: P Sanders	Saudi Aramco, Dahrn	SA
1: G Eldridge, E Garo, M Goering, <i>et al.</i>	Sequoia Sciences, San Diego	CA
2: D Vogel	Smith & Nephew, Memphis	TN
1: R Wolcott, MD	SRWCC, Lubbock	TX
1: A Haag, M Mittleman	Specialty Biopolymers, Bozeman	MT
1: C Davis, J Flood, J Semour, K Kerr, <i>et al.</i>	The Procter & Gamble Co., Cincinnati	OH

**RESEARCH COLLABORATION**

Haluk Beyenal,  
Washington State  
University,  
Pullman, WA  
(Lewandowski)



**Teaching what she practices**

Formerly a high school science teacher herself, Elinor Pulcini, CBE research manager for the Medical Biofilm Laboratory, now shares her microbiology expertise with other science teachers through MSU's Master of Science in Science Education (MSSE) degree program. The MSSE program combines online courses with opportunities for on-campus summer experiences—allowing science teachers to earn a graduate degree without leaving their teaching positions. Elinor has taught online classes on topics ranging from environmental microbiology to microbial genetics for more than five years.

In the 2007 fall semester, Elinor taught her first microbial biofilms course. “**Biofilms: An introduction to the diversity of slime**” drew 15 science teachers from across the US, as well as China and Mexico. And she

proved that distance learning does not have to be distancing. One student summed up the experience in this way: “Your technique of keeping us at the leading edge of science through timely journal articles and challenging us to think through the myriad possibilities was excellent. The class discussions were particularly lively and energizing.” Information about the MSU MSSE program is available at <http://www.montana.edu/msse/>

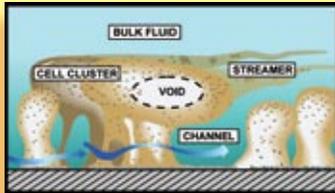
# OUTREACH

**Have you seen this biofilm?**

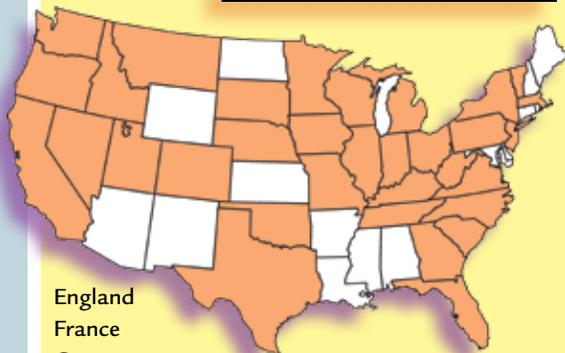
Web requests for use of CBE images from the online **Image Library** came in from 33 of the United States.

**PLUS:**

- Australia
- Belgium
- Brazil
- Canada
- Denmark



Japanese students from the Oita Maizuru Super Science High School have visited the CBE for the past two years. Technical operations manager John Neuman (above left) took the students on a tour of the CBE's laboratories to explain the CBE's biofilm research. This Super Science school has chosen to focus all of its study on biofilms, so the CBE was a reported high spot on their trip to the US. This year the students took a turn at showing what they had learned about biofilms by presenting a slide show that they created during the past year.



England			
France			
Germany			
Greece	Mexico	<b>Academic</b>	<b>51%</b>
India	Netherlands	<b>Acad., medical</b>	<b>14%</b>
Ireland	Poland	<b>Industry</b>	<b>17%</b>
	Slovenia	<b>Publishers</b>	<b>7%</b>
	South Africa	<b>Govt. agencies</b>	<b>4%</b>
	Taiwan	<b>Other</b>	<b>6%</b>

A summary of requesters:

**RESEARCH COLLABORATION**

Zhili He & Jizhong Zhou,  
University of Oklahoma,  
Norman, OK  
(Fields)



# 14 outreach

## Biofilm Mechanics workshop

*An interdisciplinary research retreat  
June 28–30, 2007 in Bozeman*



This event brought together 26 researchers 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. A free afternoon allowed for fishing, hiking, beer sipping, and project planning. Ideas and themes that emerged during the retreat are summarized in the Appendix. All participants were enthusiastic about the value of this type of interaction and its potential for producing good ideas on a variety of biofilm topics.

*Pictured top: Workshop organizers Paul Stoodley, Phil Stewart, and Isaac Klapper; bottom, an afternoon excursion to Lava Lake.*

# outreach

**Phil Stewart**, front row, fourth from left, 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**, far right. The two groups have hosted reciprocal workshops and visits regularly since 2001. The entire workshop group is pictured below.



## Visiting researchers, 2007–2008

**Diana Amari**, graduate student, Binghamton University, NY

**Virginia Anderson**, faculty, Towson State University, MD

**Haluk Beyenal**, faculty, Washington State University, Pullman, WA

**Eliora Bujari**, undergraduate student, Manhattan College, Riverside, NY

**Abdoulaye Camara**, student, Bamako, Mali

**Greg Characklis**, faculty, University of North Carolina–Chapel Hill, NC

**Chris Groth**, graduate student, Manhattan College, Riverside, NY

**Kim Harris**, researcher, Procter & Gamble, Egham, United Kingdom

**Lourdes Jiménez Taracido**, graduate student, University of Cádiz, Spain

**John Lennox**, retired faculty, Penn State Altoona, PA

**Hung Nguyen**, graduate student, Washington State University, Pullman, WA

**Sonia Porta Banderas**, research scholar, Ainia Centro Tecnológico, Valencia, Spain

**Susana Sánchez**, graduate student, University of Navarra, Spain

**Priscilla Sossa**, graduate student, University of Antofagasta, Chile

## CHILEAN INTERACTION

*Homero Urrutia,  
University of  
Concepción,  
Chile  
(several CBE  
faculty, staff,  
& students)*



MSU honored **Joe Seymour**, associate professor of chemical and biological engineering, with the **Cox Family Award for Creative Scholarship and Teaching** in May 2008. He received a \$2,000 honorarium from the Winston and Helen Cox Family Endowment as well as an \$800 stipend to be used to purchase books dedicated in his honor at MSU's Renne Library.



**Bruce McLeod**, professor of electrical engineering and former dean of graduate studies at Montana State University, was recognized for **contributions to the development and operation**

**of the Great Plains Interactive Distance Education Alliance** on April 8, 2008, in Kansas City, Missouri. While dean of graduate studies at MSU, McLeod recognized that students needed programs that MSU was unable to offer independently. As part of Great Plains IDEA, McLeod and colleagues were instrumental in establishing processes that allowed the alliance to launch its shared degree programs.

**Brent Peyton**, an associate professor in chemical and biological engineering, received the **2008 MSU College of Engineering Excellence in Research** award.



**RESEARCH COLLABORATION**

*Judy Wall, University of Missouri, Columbia, MO (Fields)*



**Darla Goeres** was awarded the **2008 CBE Outstanding Faculty Award** in recognition of her leadership of the Standardized Biofilm Methods group; her initiative in engaging industry, regulators, and standard-setting

organizations; and perseverance and success in bringing in major new EPA funding.

**Peg Dirckx** received an award at the 2007 summer Technical Advisory Conference for her **contributions to CBE research efforts** through visual and verbal communications.



# NOTEWORTHY

**New employees**

**Mary Cloud Ammons**, Postdoctoral Research Associate, Medical Biofilm Lab

**James Folsom**, Postdoctoral Research Associate, Biofilm Control

**Tara Gunsch**, Human Resources Specialist

**Carol Leist**, Administrative Assistant

**Chelsea Lipp**, Research Assistant, Medical Biofilm Lab

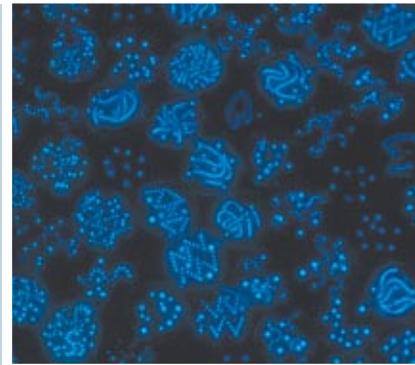
**RESEARCH COLLABORATION**

*Ron Sims, Utah State, Logan, UT; Steven Billingsley, Inland Northwest Research Alliance, Idaho Falls, ID (Cunningham)*

**Andy Mitchell**, Assistant Research Professor

**Karen Moll**, Research Assistant, Standardized Biofilm Methods

**Brad Ramsay**, Research Associate, Physiology & Ecology



**Bioglyphs still haven't lost their glow**

The August 2007 issue of *Microbiology Today* featured a photograph from the MSU Bozeman Bioglyphs Project, a collaboration between the CBE and the MSU School

of Art. A Bioglyphs photo appeared in the article "**The aesthetic microbe: ProkaryArt and EukaryArt**," by Simon Park, School of Biomedical and Molecular Sciences, University of Surrey, UK. A Bioglyphs image will also be featured in a new art/science book by San Francisco State University professor Stephen Wilson entitled *Border Watch: Artists Working at the Frontiers of Research* (Thames & Hudson, 2008).

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Biofilm  
Engineering**



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**On the front cover:**

*Top: Annabelle Morales, Rohm and Haas, and Michael Beach, CDC, participate in a CBE biofilm methods workshop.*

*Bottom: A summer 2007 photo of the Industrial and Environmental Water Systems research group led by Anne Camper, professor in civil engineering, provides a striking example of the geographic diversity valued at the CBE. Back row from left are: Taimur Khan, Bangladesh; Ben Hisey, MT, USA; Sabrina Behnke, Germany; Markus Dieser, Austria; Jennifer Faulwetter, USA; Kevin Grabinski, MT, USA; Shahed Rahman, Bangladesh; Mark Burr, MT, USA; Christine Foreman, MT, USA; Andreas Nocker, Germany; Sidy Ba, Mali; Priscilla Sossa, Chile. Front row from left are: Gem Encarcion, the Philippines; Diana Amari, visiting student from New York; Anne Camper, MT, USA; Henriette Geier, Germany; Lynne Leach, USA; Stewart Clark, South Africa.*



*Informal gatherings, like this dinner at the local Rockin' TJ Ranch at the 2007 summer Technical Advisory Conference, provide the opportunity to get better acquainted with our industrial members.*



**RESEARCH  
COLLABORATION**

*Andre Nantel,  
McGill University,  
Montreal, Canada  
(Suci)*

**Report Contributors:** *Members of the MSU Center for Biofilm Engineering faculty, staff, students, and visitors.*

**Executive editor:** *Phil Stewart*  
**Design & editing:** *Peg Dirckx*

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**RESEARCH  
COLLABORATION**

*Garth Ehrlich,  
Allegheny-Singer  
Research Institute,  
Pittsburgh, PA  
(Stewart, McLeod)*



*A fall 2007 afternoon retreat for CBE faculty and support staff provided an opportunity to brainstorm ideas for future goals and projects—and to share a laugh or two.*