APPENDIX

Center for Biofilm Engineering

Montana State University
Bozeman

Reporting Period:
June 1, 2018–May 31, 2019
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- Faculty and staff awards and appointments

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**RESEARCH:**

**CBE RESEARCH AREAS**

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

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

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

### APPLIED RESEARCH AREAS & PROJECTS

- **Biofilm control strategies** antimicrobial efficacy | biocides | bioelectric effect | disinfectants | inhibitory coatings | bioactive compounds
- **Energy solutions** biofuels | product souring | coal bed methane production | microbial fuel cells
- **Environmental technologies** bioremediation | wetlands | CO₂ sequestration | biobars | biomineralization | microbes & mining issues
- **Health/medical biofilms** chronic wound healing | catheter infections | oral health | food safety
- **Industrial systems & processes** biofouling | biocorrosion | product contamination | microbe-metal interactions
- **Standardized methods** product claims | regulatory issues | ASTM methods acceptance
- **Water systems** drinking water quality | premise plumbing | water treatment | distribution systems

### FUNDAMENTAL TOPICS

- **Biofilms in nature** microbes in hot & cold environments | role of biofilms in natural processes | biomimetics | biogeochemistry
- **Cellular/intracellular** phenotype | genetics | metabolic pathways | proteomics
- **Multicellular/extracellular** flow and transport in biofilm systems | material properties | quorum sensing | structure-function | heterogeneities | matrix
- **Ecology/physiology** population characterization | spatial and temporal population dynamics

### ANALYTICAL TOOLS & TECHNIQUES

- **Instrumentation** microscopy | nuclear magnetic resonance imaging | gas chromatography | microfluidics
- **Methods development** experimental design | variability | ruggedness | repeatability | statistical evaluation
- **Modeling** cellular automata modeling | mathematics | hydrodynamics | cohesive strength
- **Basic microbiology techniques** total and direct counts | MIC determination | viable cell counts
- **Molecular biology techniques** DNA extraction | PCR | DGGE | microarrays | sequencing
## RESEARCH:

### 2018–2019 CBE GRANT-FUNDED RESEARCH ACTIVITY

<table>
<thead>
<tr>
<th>Research Area</th>
<th>Title</th>
<th>Principal Investigator</th>
<th>Funding Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofilm Mechanics</td>
<td>Exploring Biofilm Material Properties with Micromechanical Tools</td>
<td>Wilking</td>
<td>NSF</td>
</tr>
<tr>
<td>Biofilm Mechanics</td>
<td>Collaborative Research: Modeling Gastric Mucus Layer Physiology with Application to Helicobacter Pylori and Gastric Organoids</td>
<td>Wilking</td>
<td>UTAUNI</td>
</tr>
<tr>
<td>Biofilm Mechanics</td>
<td>3D-Printing of Microbial Communities for Optimal Resource Processing</td>
<td>Wilking</td>
<td>ARREOF</td>
</tr>
<tr>
<td>Biofilm Mechanics</td>
<td>VIPER: Viral Interdiction through Population Engineering and Restructuring</td>
<td>Chang</td>
<td>NCSU</td>
</tr>
<tr>
<td>Biofilm Mechanics</td>
<td>CAREER: Understanding Spatial Heterogeneity in Biofilms Using Colloidal Engineering</td>
<td>Chang</td>
<td>NSF</td>
</tr>
<tr>
<td>Biofilms in Nature</td>
<td>SLICE: Spectral Signs of Life in Ice</td>
<td>Foreman</td>
<td>NASA</td>
</tr>
<tr>
<td>Biofilms in Nature</td>
<td>Eradication of Microbial Contamination in Metal Working Fluids</td>
<td>Foreman</td>
<td>NSF</td>
</tr>
<tr>
<td>Biofilms in Nature</td>
<td>Continued Monitoring of the Bridger Bowl Wetland System</td>
<td>Stein</td>
<td>Bridger Bowl</td>
</tr>
<tr>
<td>Energy Solutions</td>
<td>Lipid derived biofuels: Bicarbonate induced triacylglycerol accumulation in microalgae</td>
<td>Peyton</td>
<td>Church &amp; Dwight</td>
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<tr>
<td>Environmental Substance Technologies</td>
<td>Cooperative research program on constructed wetland design and implementation</td>
<td>Stein</td>
<td>USFWS</td>
</tr>
<tr>
<td>Environmental Substance Technologies</td>
<td>Building Genome-to-Phenome Infrastructure for Regulating Methane in Deep &amp; Extreme Environments</td>
<td>Gerlach</td>
<td>South Dakota School of Mines</td>
</tr>
<tr>
<td>Environmental Substance Technologies</td>
<td>Application of Biofilm Covered Carbon Particles as a Microbial Inoculum Delivery System in Weathered PCB Contaminated Sediment*</td>
<td>Stewart</td>
<td>University of Maryland</td>
</tr>
<tr>
<td>Environmental Substance Technologies</td>
<td>Sulfate reducer biofilm transcriptomics and thermodynamics under transient conditions</td>
<td>Fields</td>
<td>EXXMOB002</td>
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<tr>
<td>Environmental Substance Technologies</td>
<td>Developing Biomineralization Technology for Ensuring Wellbore Integrity</td>
<td>Gerlach</td>
<td>Montana Emergent Technologies Inc</td>
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<td>Environmental Substance Technologies</td>
<td>Bio-cement Coating of Waste Ores and Tailings</td>
<td>Lauchnor</td>
<td>Pegasus Technical Services</td>
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<td>Environmental Substance Technologies</td>
<td>Permeability Control for Enhanced Oil and Gas Recovery in Unconventional Reservoirs Using Advanced Mineral Precipitation Technologies</td>
<td>Phillips</td>
<td>Montana Emergent Technologies Inc</td>
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<td>Environmental Substance Technologies</td>
<td>A comprehensive strategy for stable, high productivity cultivation of microalgae with controllable biomass composition</td>
<td>Gerlach</td>
<td>University of Toledo</td>
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<td>Medical Biofilms</td>
<td>Resensitization of Bacteria in Biofilms to Antibiotics</td>
<td>Stewart</td>
<td>DOD (USAMRAA)</td>
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<td>Medical Biofilms</td>
<td>Synergy between omics, symptoms, and healing trajectories of venous ulcers</td>
<td>Stewart</td>
<td>University of Florida</td>
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<tr>
<td>Medical Biofilms</td>
<td>Designing Immunomodulatory Antibiofilm Biomaterials</td>
<td>Stewart</td>
<td>University of Copenhagen</td>
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<td>Methods Development</td>
<td>Methods to assess biofilm prevention on medical devices</td>
<td>Goeres</td>
<td>Burroughs Wellcome Fund</td>
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<td>Methods Development</td>
<td>Antimicrobial Test Method - Statistical Support &amp; Consultation</td>
<td>Goeres</td>
<td>EPA</td>
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<td>Methods Development</td>
<td>Biofilm and Biomineralization Methods Development in Support of CRC 1313 Projects C04 and C05</td>
<td>Cunningham</td>
<td>Deutsche Forschungsgemeinschaft</td>
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<tr>
<td>Modeling</td>
<td>Predictive Multiscale Modeling of Microbial Consortia Biofilms</td>
<td>Carlson</td>
<td>NIH</td>
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<td>Modeling</td>
<td>Development of Robust Microbial Communities through Engineered Biofilms</td>
<td>Carlson</td>
<td>ARREOF</td>
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<td>Modeling</td>
<td>A Robust Biofilm-Biomat Reactor for Conversion of Mission-Relevant Feedstocks to Products</td>
<td>Carlson</td>
<td>Sustainable Bioproducts</td>
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<tr>
<td>Physiology &amp; Ecology</td>
<td>Environmental Networks Integrated with Genomes and Molecular Assemblies</td>
<td>Fields</td>
<td>Lawrence Berkley National Laboratory</td>
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<tr>
<td>Physiology &amp; Ecology</td>
<td>Mineral Recovery from Urine - An Alternative Approach for Providing Nutrient for Primary Production in a Controlled Ecological Life Support System for Long-Term Space Missions¹</td>
<td>Gerlach</td>
<td>NASA</td>
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<tr>
<td>Water Systems</td>
<td>Strengthening Little Big Horn College Research Capacity through Improving Rural Families’ Access to Safe Drinking Water, Crow Reservation, Montana</td>
<td>Eggers</td>
<td>Little Bighorn College</td>
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¹NASA EPSCOR
### FY19 New CBE Research Grants (July 1, 2018 to June 30, 2019)

<table>
<thead>
<tr>
<th>Sponsor</th>
<th>Title</th>
<th>PI</th>
<th>Period</th>
<th>Award Amount</th>
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<tr>
<td>University of Maryland</td>
<td>Application of Biofilm Covered Carbon Particles as a Microbial Inoculum Delivery System in Weathered PCB Contaminated Sediment*</td>
<td>Phil Stewart</td>
<td>1 Yr</td>
<td>$4,992</td>
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<td>Bridger Bowl</td>
<td>Continued Monitoring of the Bridger Bowl Wetland System*</td>
<td>Otto Stein</td>
<td>3 Yr</td>
<td>$92,288</td>
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<tr>
<td>Pegasus Technical Services</td>
<td>Bio-cement Coating of Waste Ores and Tailings*</td>
<td>Ellen Lauchnor</td>
<td>10 months</td>
<td>$22,800</td>
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<tr>
<td>Montana Emergent Technologies</td>
<td>Permeability Control for Enhanced Oil and Gas Recovery in Unconventional Reservoirs Using Advanced Mineral Precipitation Technologies</td>
<td>Adie Phillips</td>
<td>6 months</td>
<td>$40,000</td>
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<tr>
<td>National Science Foundation</td>
<td>Eradication of Microbial Contamination in Metal Working Fluids</td>
<td>Christine Foreman</td>
<td>3 Yr</td>
<td>$316,495</td>
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<td>University of Utah</td>
<td>Collaborative Research: Modeling Gastric Mucus Layer Physiology with Application to Helicobacter Pylori and Gastric Organoids</td>
<td>James Wilking</td>
<td>3.5 Yr</td>
<td>$104,356</td>
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<tr>
<td>University of Toledo</td>
<td>A comprehensive strategy for stable, high productivity cultivation of microalgae with controllable biomass composition</td>
<td>Robin Gerlach</td>
<td>3.5 Yr</td>
<td>$1,156,293</td>
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<td>Arrevus Inc</td>
<td>Development of a predictive moderate throughput assay to screen novel Designer Proline-rich antimicrobial peptide Chaperone protein inhibitors (DPCs) against multi-drug resistant pathogens</td>
<td>Garth James</td>
<td>1 Yr</td>
<td>$89,834</td>
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<tr>
<td>Sustainable Bioproducts</td>
<td>A Robust Biofilm-Biomat Reactor for Conversion of Mission-Relevant Feedstocks to Products</td>
<td>Ross Carlson</td>
<td>1 Yr</td>
<td>$37,500</td>
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<td>US Army Research Office</td>
<td>3D-Printing of Microbial Communities for Optimal Resource Processing</td>
<td>James Wilking</td>
<td>2 yr</td>
<td>$679,072</td>
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<tr>
<td><strong>Total Grant Awards to CBE in Fiscal Year 2019</strong></td>
<td></td>
<td></td>
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<td><strong>$2,543,630</strong></td>
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*Additional funding awarded to existing grants in FY19 (budget increased by the amount listed)
RESEARCH:
PUBLICATIONS
June 2018–May 2019

2018 Publications

NOTE:
2018-001 through 2018-018 are listed in 2018 Appendix

2018 Publications


Simkins JW, Stewart PS, Seymour JD, “Spatiotemporal mapping of oxygen in a microbially-impacted packed bed using 19F nuclear magnetic resonance oximetry,” J Magnetic Resonance, August 2018; 293:123-133. 2018-020


2019 Publications


Arbogast JW*, Bowersock L, Parker AE, Macinga DR, “Randomized controlled trial evaluating the antimicrobial...


^Undergraduate student
† Industrial or Federal Agency co-author
*Previous Visiting Researcher
# Previous staff/faculty

#: 42

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RESEARCH:
PRESENTATIONS
June 2018–May 2019

The following CBE faculty presented research at the ASM Microbe 2018 Conference, June 7–11, 2018, in Atlanta, GA:

Christine Foreman, associate professor, chemical and biological engineering, as an invited plenary speaker presented “Microbes, carbon and climate: Exploring the impacts of a changing cryosphere.”

Darla Goeres, associate research professor, chemical & biological engineering, as an invited speaker presented “Standard methods and public health: Review and evaluation of case study data through an academic, regulatory, and public health perspective.”

John Doyle, project coordinator, microbiology & immunology, CBE research engineer, presented “Climate Adaptation and Waterborne Disease Prevention, Crow Reservation in Montana,” at the Tribal Environmental Health Summit, June 25–26, 2018, Corvallis, OR.

Diane Walker, CBE research engineer, Kelli Buckingham-Meyer, CBE Research Assistant III, and Albert Parker, CBE statistician, conducted a workshop “Standardized Biofilm Methods for Laboratory Studies of Biofilms,” at the International Association for Food Protection (IAFP), July 6-8, 2018, Salt Lake City, UT.

Neerja Zambare, PhD student, chemical & biological engineering, presented “Multi-scale microscopy of microbially induced calcium carbonate precipitation,” at the Microscopy & Microanalysis 2018 Meeting, August 5-9, 2018, Baltimore, MD.

The following CBE researchers presented their work at the 17th International Symposium on Microbial Ecology in Leipzig, Germany from August 13-16, 2018:

Roland Hatzenpichler, assistant professor, chemistry & biochemistry, as a keynote speaker presented “In situ activity and metabolism of uncultured thermophiles experimentally determined at single cell resolution through Next Generation Physiology.”

Luke McKay, assistant research professor, land resources & environment science, presented “Genomic potential for anaerobic methane and dissimilatory sulfur metabolism discovered in the Korarchaeota.”

Gregory Krantz, PhD student, microbiology & immunology, presented “Large extracellular novel proteins essential to Desulfovibrio vulgaris Hildenborough biofilm formation,” at the Society for Microbiology and Biotechnology Conference, August 13-15, 2018, Chicago, IL.

Neerja Zambare presented “Controlling strontium partitioning during MICP under continuous flow,” at the Goldschmidt Conference, August 13-16, 2018, Boston, MA.

Matthew Fields, CBE director, professor, microbiology & immunology, presented “Metabolisms of bacteria involved in MIC” at the EUROCORR conference, September 8-12, 2018, Krakow, Poland.

Darla Goeres presented “Biofilms in draught beer lines: Besting the bacteria in beer,” Draught Quality Summit, September 20–21, 2018, Denver, CO.

Al Parker presented “Bayesian analysis and design of experiments of biofilms over space and time,” Applied Math Seminar at MSU, Bozeman, MT, September 27, 2018.

Mari Eggers, CBE research scientist and John Doyle, project coordinator, microbiology & immunology, presented “Merging science and technology with culture and tradition: A panel discussion,” Water Environment Federation, September 30–October 1, 2018, New Orleans, LA.

Phil Stewart, professor, chemical & biological engineering, presented “Critical parameters for neutrophil control of nascent biofilm,” at the 7th Thesinge Biofilm Meeting, Groeningen, The Netherlands, October 1-2, 2018.

**Garth James**, associate research professor, chemical & biological engineering, presented “Bacterial adhesion and biofilm formation on textured breast implant shell materials, at the 4th World Symposium on Ergonomic Implants, October 8–9, 2018, Gardone, Lago di Garda, Italy.

The following CBE researchers participated in the 8th ASM Conference on Biofilms, Washington DC, October 10–11, 2018:

**Presenters:**
- **Kelli Buckingham-Meyer, Darla Goeres, Al Parker, and Diane Walker** hosted a workshop “Standardized Biofilm Methods.”
- **Mike Franklin**, professor, microbiology & immunology, presented “Ribosome hibernation in dormant *Pseudomonas aeruginosa* biofilm cells.”
- **Brian Pettygrove**, PhD student, microbiology & immunology, presented “Neutrophil clearance of nascent *Staphylococcus aureus* biofilm.”
- **Phil Stewart** served as a session chair and program committee member. He also presented “Oxygen limitation, starvation stress responses,” and “Extracellular polysaccharide synthesis contribute to Ciprofloxacin tolerance in a *Pseudomonas aeruginosa* biofilm.”

**Poster:**
- **Danica Walsh**, PhD student, chemistry & biochemistry, presented “The design synthesis and evaluation of prodrug antimicrobials to control biofilms.”

The following CBE researchers presented their work at the Algae Biomass Summit, Houston TX, Oct. 15–16, 2018:

**Speakers:**
- **Robin Gerlach**, professor, chemical & biological engineering, “Maximizing the benefits of combined algae cultivation and wastewater treatment through a better understanding of organic carbon utilization by three green algae species.”

**Matthew Jackson**, PhD student, chemical & biological engineering, presented “Improved productivity during combined wastewater treatment and algae cultivation: Understanding nitrogen assimilation under low and high alkalinity conditions.”

**Nickolas Avila**, undergraduate, chemical & biological engineering, presented “Quantifying enhanced mass transfer of CO₂ into high alkalinity algae culture medium.”

**Poster Presenters:**
- **Nickolas Avila** presented “Thermophilic, high alkalinity microalgal enrichment from a Yellowstone National Park hot spring outflow cyanobacterial mat.”
- **Berrak Erturk**, masters student, chemical & biological engineering, presented “Sodium bicarbonate amendment for enhanced astaxanthin production from *Haematococcus pluvialis*.”
- **Calvin Cicha**, PhD student, microbiology & immunology, presented “Genome annotation of coal bed methane production water isolate PW95.”
- **Hannah Goemann**, PhD student, microbiology & immunology, presented “Impact of a cyanobacterial biofertilizer on switchgrass production and the soil microbiome.”
- **Matthew Jackson** presented “Bicarbonate amendment at nitrogen depletion for enhanced lipid accumulation under different nitrogen and carbon regimes.”


**Roland Hatzenpichler**’s research into the Guaymas deep sea basin was covered in a one-minute radio segment by the Northern News Network and NPR on January 17, 2019. The project is funded by NSF.

**Phil Stewart** was invited to present two talks at Nanyang Technological University (NTU) in Singapore: “How bacteria persist in biofilms,” Jan. 23, 2019.


Roland Hatzenpichler was invited to present “Next generation physiology: Determining in situ metabolisms of uncultured microbes at single cell resolution and high throughput,” at the John Lawrence Seminar, Lawrence Berkeley National Laboratory, Berkeley, CA, March 19, 2019.

Phil Stewart presented “Strategies for preventing biofilm infections on medical devices,” at the University of Calgary, Canada, March 22, 2019.


Al Parker presented “Interlaboratory study design for antimicrobial test methods,” at ASTM Committee E35 Meeting, Denver, CO, April 2, 2019.


The following CBE researchers participated in InterPore 2019, Valencia, Spain, May 6–10, 2019.

Al Cunningham, professor emeritus in civil engineering, Adie Phillips, assistant professor in civil engineering, and Robin Gerlach were part of the organizing committee for the mini symposia “Biochemical processes and biofilms in porous media.”

Invited presentations:

Catherine Kirkland, assistant research professor, civil engineering: “MICP in the field: Continuous injection to reduce permeability and enhance wellbore integrity.”

Brent Peyton, professor, chemical & biological engineering: “In situ bioremediation of selenium and nitrate for mine waste management in the Elk Valley, British Columbia.”

Neerja Zambare*: “Improved understanding of microbe-mineral interactions using droplet-based microfluidics.” *Neerja won an MSU Graduate School travel grant to present at this meeting.

Poster Presentations:

Arda Akyel, PhD student, chemical & biological engineering, “Thermal stability of urease produced by Sporosarcina pasteurii.”

Dalton Albers, masters student, chemical & biological engineering, “Thermally induced calcium carbonate precipitation in the Bakken oilfields.”

Sobia Anjum, PhD student, chemical & biological engineering, “Relating mechanical properties of biofilm-mineral composites to bulk porous media properties.”

Zachary Frieling, masters student, chemical & biological engineering, “Urease immobilization for advancing enzyme-induced calcium carbonate precipitation applications.”
## RESEARCH:
### CBE Affiliated Faculty and Their Specialties, 2018–2019

<table>
<thead>
<tr>
<th>NAME</th>
<th>DEPARTMENT</th>
<th>SPECIALTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elliott Barnhart</td>
<td>Center for Biofilm Engineering</td>
<td>Environmental biotechnology</td>
</tr>
<tr>
<td>Roberta Amendola</td>
<td>Mechanical &amp; Industrial Engineering</td>
<td>Material science and technology</td>
</tr>
<tr>
<td>Jennifer Brown</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Rheology and biofilm mechanics</td>
</tr>
<tr>
<td>Anne Camper</td>
<td>Civil Engineering</td>
<td>Biofilms in environmental systems; water distribution</td>
</tr>
<tr>
<td>Ross Carlson</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Metabolic eng., metabolic networks; chronic wounds</td>
</tr>
<tr>
<td>Connie Chang</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Microfluidics</td>
</tr>
<tr>
<td>Sarah Codd</td>
<td>Mechanical &amp; Industrial Engineering</td>
<td>Magnetic resonance imaging</td>
</tr>
<tr>
<td>Kevin Cook</td>
<td>Mechanical &amp; Industrial Engineering</td>
<td>Tool and machine design</td>
</tr>
<tr>
<td>Al Cunningham</td>
<td>Civil Engineering</td>
<td>Subsurface biotechnology and bioremediation</td>
</tr>
<tr>
<td>Markus Dieser</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Ecology</td>
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<tr>
<td>Erika Espinosa-Ortiz</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Environmental technologies</td>
</tr>
<tr>
<td>Matthew Fields</td>
<td>Microbiology &amp; Immunology</td>
<td>Environmental biofilms</td>
</tr>
<tr>
<td>Christine Foreman</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Microbial ecology in cold temperature environments</td>
</tr>
<tr>
<td>Michael Franklin</td>
<td>Microbiology &amp; Immunology</td>
<td>Molecular genetics, gene expression, alginate biosynthesis; <em>Pseudomonas</em></td>
</tr>
<tr>
<td>Robin Gerlach</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Environmental biotechnology and bioremediation</td>
</tr>
<tr>
<td>Darla Goeres</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Standardized biofilm methods</td>
</tr>
<tr>
<td>Martin Hamilton</td>
<td>Mathematical Sciences</td>
<td>Mathematics and statistics</td>
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<tr>
<td>Roland Hatzenpichler</td>
<td>Chemistry &amp; Biochemistry</td>
<td>Microbial activity</td>
</tr>
<tr>
<td>Jeffrey Heys</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Fluid-structure interactions</td>
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<tr>
<td>Garth James</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Medical biofilms</td>
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<tr>
<td>Kelly Kirker</td>
<td>Chemical &amp; Biological Engineering</td>
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<td>Catherine Kirkland</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Environmental technologies</td>
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<tr>
<td>Ellen Lauchnor</td>
<td>Civil Engineering</td>
<td>Wastewater Systems</td>
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<tr>
<td>Zbigniew Lewandowski</td>
<td>Civil Engineering</td>
<td>Microsensors, chemical gradients, biofilm structure</td>
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<tr>
<td>Luke McKay</td>
<td>Land Resources and Environ. Sciences</td>
<td>Biofilms in extreme environments, metagenomics</td>
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<td>Albert Parker</td>
<td>Mathematical Sciences</td>
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<tr>
<td>Brent Peyton</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Environmental biotechnology and bioremediation</td>
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<td>Adrienne Phillips</td>
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<td>Elinor Pulcini</td>
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<td>Medical biofilms</td>
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<td>Abbie Richards</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Environmental biotechnology</td>
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<td>Cecily Ryan</td>
<td>Mechanical &amp; Industrial Engineering</td>
<td>Polymers &amp; composites</td>
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<tr>
<td>Name</td>
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<td>Research Focus</td>
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<tr>
<td>Joseph Seymour</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Magnetic resonance imaging</td>
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<tr>
<td>Dana Skorupa</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Microbes in extreme environments</td>
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<tr>
<td>Otto Stein</td>
<td>Civil Engineering</td>
<td>Engineered waste remediation</td>
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<tr>
<td>Heidi Smith</td>
<td>Microbiology &amp; Immunology</td>
<td>Biology, imaging</td>
</tr>
<tr>
<td>Phil Stewart</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Biofilm control strategies</td>
</tr>
<tr>
<td>Paul Sturman</td>
<td>Civil Engineering</td>
<td>Biofilms in waste remediation, industrial systems</td>
</tr>
<tr>
<td>Stephan Warnat</td>
<td>Mechanical &amp; Industrial Engineering</td>
<td>MEMS, sensors and actuators</td>
</tr>
<tr>
<td>James Wilking</td>
<td>Chemical &amp; Biological Engineering</td>
<td>Physical and material biofilm properties</td>
</tr>
<tr>
<td>Tianyu Zhang</td>
<td>Mathematical Sciences</td>
<td>Mathematical modeling</td>
</tr>
</tbody>
</table>
CBE recognized by MSU as leader in research activity
CBE was recognized as a top contributor to MSU’s research expenditures for fiscal year 2018, according to MSU’s Office of Research and Economic Development. The university reported expenditures totaling $126.5 million, marking one of its strongest years for research. The Norm Asbjornson College of Engineering was one of the top three colleges for expenditures, led by the CBE, the Department of Electrical Engineering, and Western Transportation Institute. The article “MSU records yet another strong year for research,” published by MSU News and featured in the Bozeman Daily Chronicle, also highlights the research activity of several MSU researchers including CBE affiliated faculty members Connie Chang and Darla Goeres.

CBE faculty member awarded grant to study how deep-microorganisms break down carbon
CBE affiliated faculty member Roland Hatzenpichler, assistant professor in chemistry and biochemistry, was featured by MSU News for his receipt of a $1 million award from NSF to collect microbe-rich sediments from the floor of Guaymas Basin, located in the Gulf of California. “MSU biochemist awarded grant to study how deep-sea microorganisms break down carbon”

CBE researchers explain how life-threatening bacterium can withstand antibiotics
At the CBE’s summer 2018 Montana Biofilm Meeting, Phil Stewart shared findings about how a bacterium that causes serious wound infections can tolerate common medical treatments. “MSU biofilm researchers explain how life-threatening bacterium can withstand antibiotics”

MSU algae research could make biofuel production more economical
In an effort to improve the feasibility of a renewable energy source, Montana State University researchers are exploring a potential breakthrough in producing biofuel from algae. Four CBE affiliated faculty members are PIs on the project. Read the full article at MSU News.

Two scientific journals featured CBE images on their covers
The separate works of a faculty member and a PhD student at the Center for Biofilm Engineering have been featured on the covers of prominent scientific journals.

Garth James, associate research professor in chemical and biological engineering and the principal investigator of CBE’s Medical Biofilms Laboratory, took part in an expert panel that recommended in 2017 that physicians adopt an aggressive treatment protocol for chronic wounds. The expert panel’s recommendation was featured on the cover of the September 2017 issue of Wound Repair and Regeneration for the article “Consensus guidelines for the identification and treatment of biofilms in chronic nonhealing wounds.”

Jeffrey Simkins, a CBE PhD student in chemical and biological engineering, created the cover image for the August 2018 issue of the Journal of Magnetic Resonance. Simkins is also the first author of the feature article that details a study that pioneers a new, MRI-based technique to measure oxygen distribution in biofilms that exploits the sensitivity of fluorocarbons to local oxygen concentration. Read
Stewart, James part of NIH grant addressing chronic wounds
Phil Stewart and Garth James, both CBE affiliate faculty in chemical and biological engineering, are collaborating with nursing and medical investigators at the University of Florida on the NIH-funded project “Biobehavioral mechanisms underlying symptoms and healing outcomes in older individuals with chronic venous leg ulcers.” The research program aims to enhance the health outcomes of older individuals with chronic non-healing wounds by elucidating the complex biobehavioral factors that influence the trajectory of healing and patient-oriented symptoms, including distressing pain, fatigue, and depression. A longitudinal analysis of clinical wound debridement specimens for the presence of biofilm and characterization of their microbial communities by DNA sequencing is an integral component of the project.

CBE researchers use 3-D printing to push knowledge of microbial communities
CBE faculty member Jim Wilking, assistant professor in chemical and biological engineering, was featured by MSU News for innovative work he and his students are doing with 3-D printing. Wilking is part of a team that received a grant from the US Army to use 3-D printing to push the knowledge of how microbial communities assemble and interact in biofilms.

MSU researcher co-authors paper that raises awareness of microbes’ importance to climate change
CBE affiliated faculty member Christine Foreman, associate professor in chemical and biological engineering, was featured by MSU News for her paper in Nature Reviews Microbiology that calls for greater attention to microbes when studying global climate change.

CBE postdoc first author on Nature Microbiology article
Zack Jay, CBE postdoctoral researcher, was first author on the article “Marsarchaeota are an aerobic archaeal lineage abundant in geothermal iron oxide microbial mats,” published in Nature Microbiology in May 2018. According to an article in MSU News, the research team found a new lineage of microbes living in Yellowstone National Park’s thermal features that sheds light on the origin of life and the evolutionary history of the Earth. Jay joined the CBE as a postdoc in 2016.

CBE Affiliated Faculty & Staff Awards & Appointments

2019 MSU Faculty and Staff Honors
Joe Seymour, Center for Biofilm Engineering faculty and professor in MSU’s Department of Chemical and Biological Engineering, was honored as one of Montana State University top faculty at the university’s 2019 Spring Convocation ceremony Jan. 8. The annual awards recognize and honor achievement in faculty and staff research, teaching, outreach, and creative projects. Seymour received the Provost’s Award for Graduate Research/Creative Mentoring, which recognizes a faculty member who engages graduate students in this valuable learning process.
Matthew Fields, CBE director and professor in MSU’s Department of Microbiology and Immunology, won the award last year. To read more about Seymour and other distinguished faculty and staff to be honored during the Spring Convocation ceremony, visit MSU News.

2019 College of Engineering Awards
Sarah Codd, Robin Gerlach, and Darla Goeres, each a faculty member affiliated with the Center for Biofilm Engineering, were among the honorees at the annual Norm Asbjornson College of Engineering awards luncheon held April 30. Codd, professor of mechanical and industrial engineering, received the Distinguished Professor award. Gerlach, professor of chemical and biological engineering, was honored with the Lloyd Berg Faculty Mentorship award. Goeres, associate research professor of chemical and biological engineering, received the Excellence in Outreach award. Learn about each award recipient.

Faculty Appointments
Luke McKay, former CBE postdoctoral researcher, was appointed to an assistant research professor position in MSU’s Department of Land Resources and Environmental Sciences. Luke earned his master’s and doctorate degrees from the Department of Marine Sciences at the University of North Carolina at Chapel Hill. He joined MSU in 2015 as a NASA postdoctoral fellow through the NASA Astrobiology Institute, studying primitive microbial processes in Yellowstone National Park. His research focuses on metagenomics, metatranscriptomics, stable isotope probing enrichments, and cultivation techniques to examine the distribution, functional capacity, and substrate utilization of novel archaea and bacteria in geothermal ecosystems. He will continue his CBE affiliation as a research professor.

Catherine Kirkland, former post-doctoral researcher with the CBE was recently appointed to assistant professor in MSU’s Department of Civil Engineering. Cat received her PhD in civil and environmental engineering from Montana State University. Her research focuses on a type of granular sludge that is able to break down environmental contaminants, including sources of carbon, nitrogen, and phosphorus, from wastewater. Dozens of wastewater treatment plants, primarily in Europe, currently use this emerging technology. Cat will continue her affiliated status with the CBE.

2019 CBE Outstanding Faculty Award
Robin Gerlach, professor of chemical and biological engineering, was awarded the 2019 CBE Outstanding Faculty award. Gerlach was recognized for his research activity that commands international respect, as well as his high level of industrial interaction, and work as a gifted educator. Gerlach’s activity in disseminating his findings is similarly commendable, as is his unrivaled contributions to the extraordinary growth of the field of biomineralization technology.

2019 Outstanding Researcher Award
Erika Espinosa-Ortiz, CBE postdoctoral researcher, received the CBE Outstanding Staff Award. Espinosa-Ortiz was acknowledged for her ongoing contributions to the center and outstanding work with the Industrial Associates program. She was recognized as an exemplary team player and communicator, and success as a mentor to undergraduate and graduate students alike.
New Staff
Connie Chang, assistant professor in chemical and biological engineering, welcomed two postdoctoral researchers to her lab in fall 2018. Dimitri Bikos joins the lab from UCLA where he earned his PhD and studied experimental colloidal soft matter physical chemistry specifically electrophoresis, rheology, and nanoemulsions. In Connie’s lab, he is investigating the influenza virus using single-cell drop-based microfluidic platforms. Dimitri was born in Australia, lived in Argentina until he was 6 years-old and then moved to Virginia. He enjoys studying genetic anthropology, European history and political movements, and car maintenance and repair (now we know who to talk to when our cars break down). Emma Loveday earned her PhD in microbiology and immunology from the University of British Columbia. She is researching Influenza A virus evolution, replication, and transcription at the single cell level using drop-based microfluidics. Though Emma grew up in the beach town of San Diego, snowboarding is one of her biggest passions. She has snowboarded in six different countries, in both hemispheres. Emma is also a community leader, volunteering her time with the Bozeman 500 Women Scientists Pod, an organization committed to building an inclusive scientific community and standing up for women and science. CBE and knows it will be the perfect place to explore the magical biofilm turf.

Huyen Bui joined Dr. Robin Gerlach's lab as a research scientist in April 2018. Huyen was born and raised in Vietnam. She came to the US in 2006 to pursue a PhD in molecular biology at the University of Utah. Huyen’s previous research experience includes postdoc trainings at the Cold Spring Harbor Laboratory and University of Utah, where she used genetics and genomics approaches to understand plant development and plant–herbivore interactions. In Robin’s lab, Huyen will explore the microbial community associated with algal culture and develop a molecular toolkit to improve algal fermentation for biofuel production. When not working in the lab, Huyen enjoys gardening, baking, and hiking.

In January 2019, Skip Anderson joined the CBE as a full-time communications specialist. Skip is an award-winning journalist with more than 20 years of experience in the industry, including serving nine years as a writer and editor at Vanderbilt University. Over the last two years, Skip has written more than 20 stories for MSU News including stories on several CBE affiliated faculty and researchers. He earned his BA in journalism from Belmont University in Nashville, Tennessee. At the CBE, Skip is responsible for proofing, story ideas, and all creative communications. When he’s not writing, Skip enjoys wandering the mountains and rivers in and around Bozeman with his wife and daughter.
**EDUCATION:**

**Undergraduate Students: Summer 2018, Fall 2019, Spring 2019**

<table>
<thead>
<tr>
<th>*Graduating</th>
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<tbody>
<tr>
<td>1. *Abdelgaid, Mona (Peyton)</td>
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<td>2. Anderson, Rebekah (Foreman)</td>
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<td>3. Arachchige Suraweera, Thilini (Goeres)</td>
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<td>31. *Massey, KaeLee (Fields)</td>
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<td>32. Mettler, Madelyn (Goeres)</td>
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<td>36. *Naser, Nada (Chang/Gerlach)</td>
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<td>45. *Stonebraker, Alison (Lauchnor)</td>
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<td>46. *Tunby, Paige (Gerlach/Phillips)</td>
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<td>48. Udeck, Megan (Peyton)</td>
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<tr>
<td>49. *Zeng, Jason (Wilking)</td>
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* Back to Table of Contents
## Undergraduates Summary: 2018–2019

<table>
<thead>
<tr>
<th>Department (Program)</th>
<th>Male</th>
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<th>Total</th>
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<td>Cell Biology &amp; Neuroscience</td>
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<td>Mechanical &amp; Industrial Engineering</td>
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<td>Microbiology &amp; Immunology</td>
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<td>Plant Science &amp; Plant Pathology</td>
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<tr>
<td><strong>Totals</strong></td>
<td><strong>17M</strong></td>
<td><strong>32F</strong></td>
<td><strong>49</strong></td>
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EDUCATION:

Graduate Students: Summer 2018, Fall 2019, Spring 2019

<table>
<thead>
<tr>
<th>Masters Candidates</th>
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<tbody>
<tr>
<td>1. *Albers, Dalton (Gerlach/Phillips) M Chemical &amp; Biological Engineering Great Falls, MT</td>
</tr>
<tr>
<td>2. Bowersock, Lisa (Parker) F Mathematical Sciences Rochester Hills, MI</td>
</tr>
<tr>
<td>3. Daily, Ryanne (Phillips) F Civil Engineering Great Falls, MT</td>
</tr>
<tr>
<td>4. Erturk, Berak (Peyton) F Chemical &amp; Biological Engineering Istanbul, Turkey</td>
</tr>
<tr>
<td>5. *Frieling, Zachary (Gerlach/Phillips) M Chemical &amp; Biological Engineering Gallatin Gateway, MT</td>
</tr>
<tr>
<td>6. Messmer, Mitch (Foreman) M Chemical &amp; Biological Engineering Hillsboro, OR</td>
</tr>
<tr>
<td>7. Paine, Kyle (Lauchnor) M Civil Engineering Ludington, MI</td>
</tr>
<tr>
<td>8. Panighetti, Robert (Stein) M Civil Engineering Cedarburg, WI</td>
</tr>
<tr>
<td>9. Platt, George (Fields/Gerlach) M Chemical &amp; Biological Engineering Eagle River, AK</td>
</tr>
<tr>
<td>10. Proudfoot, Dylan (Lauchnor) M Civil Engineering Fairmont, WV</td>
</tr>
<tr>
<td>11. *Raeside, Emma (Lauchnor) F Civil Engineering Rochester, NY</td>
</tr>
<tr>
<td>12. *Summers, Jennifer (Goeres) F Chemical &amp; Biological Engineering Conowingo, MD</td>
</tr>
<tr>
<td>13. Sykes, Jordan (Lauchnor) M Civil Engineering Brevard, NC</td>
</tr>
<tr>
<td>14. Thompson, Luke (Lauchnor) M Civil Engineering Littleton, CO</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PhD Candidates</th>
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<tbody>
<tr>
<td>1. Abbasi, Reha (Wilking) M Chemical &amp; Biological Engineering Istanbul, Turkey</td>
</tr>
<tr>
<td>2. Akyel, Arda (Gerlach) M Chemical &amp; Biological Engineering Istanbul, Turkey</td>
</tr>
<tr>
<td>3. Anjum, Sobia (Gerlach) F Chemical &amp; Biological Engineering Punjab, Pakistan</td>
</tr>
<tr>
<td>4. Arnold, Adrienne (Carlson) F Microbiology &amp; Immunology Charleston, WV</td>
</tr>
<tr>
<td>5. Brame, Keenan (Camper) M Chemical &amp; Biological Engineering Livingston, MT</td>
</tr>
<tr>
<td>6. *Camilleri, Laura (Fields) F Microbiology &amp; Immunology Ukiah, CA</td>
</tr>
<tr>
<td>7. Carter, Hoffman (Chang) M Chemical &amp; Biological Engineering Carlsbad, CA</td>
</tr>
<tr>
<td>8. Cicha, Calvin (Gerlach/Wiedenheft) M Microbiology &amp; Immunology Isanti, MN</td>
</tr>
<tr>
<td>9. Corredor-Arias, Luisa (Fields) F Microbiology &amp; Immunology Pereira, Colombia</td>
</tr>
<tr>
<td>10. Fredrickson, Jacob (Chang) M Chemical &amp; Biological Engineering Puyallup, WA</td>
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<tr>
<td>11. Goemann, Hannah (Peyton) F Microbiology &amp; Immunology Wells, MN</td>
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<tr>
<td>12. Jackson, Matthew (Gerlach) M Chemical &amp; Biological Engineering Naples, FL</td>
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<tr>
<td>13. Kilic, Ayse Bengisu (Lauchnor) F Chemical &amp; Biological Engineering Istanbul, Turkey</td>
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<tr>
<td>14. Koepnick, Hannah (Peyton) F Chemical &amp; Biological Engineering Sherman, TX</td>
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<tr>
<td>15. Krantz, Gregory (Fields) M Microbiology &amp; Immunology Tinton, VT</td>
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<tr>
<td>16. LeFevre, Thomas (Wilking) M Chemical &amp; Biological Engineering Escanaba, MI</td>
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<tr>
<td>17. Lynes, Mackenzie (Hatzenpichler) F Chemistry &amp; Biochemistry Cleveland, OH</td>
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<tr>
<td>18. McGill, Stacy (Carlson) M Microbiology &amp; Immunology Minor Hill, TN</td>
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<tr>
<td>19. Miller, Isaac (Fields) M Microbiology &amp; Immunology East Helena, MT</td>
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<tr>
<td>20. Moll, Karen (Peyton) F Microbiology &amp; Immunology Fairsport, NY</td>
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<tr>
<td>21. Payne, Devon (Fields) M Microbiology &amp; Immunology Henderson, NV</td>
</tr>
<tr>
<td>22. Pettygrove, Brian (Stewart) M Microbiology &amp; Immunology Leesburg, VA</td>
</tr>
<tr>
<td>23. Pratt, Shawna (Chang) F Chemical &amp; Biological Engineering Miles City, MT</td>
</tr>
<tr>
<td>24. Rathore, Muneeb (Peyton) M Chemical &amp; Biological Engineering Punjab, Pakistan</td>
</tr>
<tr>
<td>25. Reichart, Nicholas (Hatzenpichler) M Chemistry &amp; Biochemistry Bel Air, MD</td>
</tr>
<tr>
<td>26. Sanchez, Humberto (Chang) M Chemical &amp; Biological Engineering Corona, CA</td>
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<tr>
<td>27. *Schweitzer, Hannah (Fields) F Microbiology &amp; Immunology Chester, MT</td>
</tr>
<tr>
<td>28. *Sider, Barkan (Wilking) F Chemical &amp; Biological Engineering Istanbul, Turkey</td>
</tr>
<tr>
<td>29. *Simkins, Jeffrey (Stewart/Seymour) M Chemical &amp; Biological Engineering Bozeman, MT</td>
</tr>
<tr>
<td>30. Thornton, Isaa (Wilking) M Mechanical &amp; Industrial Engineering Great Falls, MT</td>
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<tr>
<td>31. Walsh, Danica (Stewart/Livinghouse) F Chemistry &amp; Biochemistry Olympia, WA</td>
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<tr>
<td>32. Zambarre, Neerja (Gerlach) F Chemical &amp; Biological Engineering Maharaswra, India</td>
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<tr>
<td>33. Zath, Geoffrey (Chang) M Chemical &amp; Biological Engineering Bend, OR</td>
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<tr>
<td>34. *Zelaya, Anna (Fields) F Microbiology &amp; Immunology Russellville, AR</td>
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<tr>
<td>35. Zeng, Jason (Wilking) M Chemical &amp; Biological Engineering Novato, CA</td>
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</tbody>
</table>

* Native American  *Received degree
### EDUCATION:
#### Graduate Students, 2018–2019

**24: Chemical & Biological Engineering**

**MS:** 7

- 5 M Albers, Dalton: MS, Gerlach
- Frieling, Zachary: MS, Gerlach
- LeFevre, Thomas: MS, Wilking
- Messmer, Mitch: MS, Foreman
- Platt, George: MS, Fields

- 2 F Erturk, Berrak: MS, Peyton
- Summers, Jennifer: MS, Goeres

**PhD:** 17

- 12 M Abbasi, Reha: PhD, Wilking
- Akyel, Arda: PhD, Gerlach
- Brame, Keenan: PhD, Camper
- Carter, Hoffman: PhD, Chang
- Fredrickson, Jacob: PhD, Chang
- Jackson, Matthew: PhD, Gerlach
- Rathore, Muneeb: PhD, Peyton
- Sanchez, Humberto: PhD, Chang
- Sidar, Barkan: PhD, Wilking
- Simkins, Jeffrey: PhD, Stewart
- Zath, Geoffrey: PhD, Chang
- Zeng, Jason: PhD, Wilking

- 5 F Anjum, Sobia: PhD, Gerlach
- Kilic, Ayse Bengisu: PhD, Lauchnor
- Koepnick, Hannah: PhD, Peyton
- Pratt, Shawna: PhD, Chang
- Zambare, Neerja: PhD, Gerlach

**3: Chemistry & Biochemistry**

**PhD:** 3

- 2 F Lynes, Mackenzie: PhD, Hatzenpichler
- Walsh, Danica: PhD, Stewart

- 1 M Reichart, Nicholas: PhD, Hatzenpichler

**7: Civil / Environmental Engineering**

**MS:** 7

- 5 M Paine, Kyle: MS, Lauchnor
- Panighetti, Robert: MS, Stein
- Proudfoot, Dylan: MS, Lauchnor
- Sykes, Jordan: MS, Lauchnor
- Thompson, Luke: MS, Lauchnor

- 2 F Daily, Ryanne: MS, Phillips
- Raeside, Emma: MS, Stein

**1: Mathematical Sciences**

**MS:** 1

- 1 F Bowersock, Lisa: MS, Parker

**1: Mechanical & Industrial Engineering**

**PhD:** 1

- 1 M Thornton, Isaak: PhD, Wilking

**13: Microbiology & Immunology**

**PhD:** 13

- 6 M Cicha, Calvin: PhD, Gerlach
- Krantz, Gregory: PhD, Fields
- McGill, Stacy: PhD, Carlson
- Miller, Isaac: PhD, Fields
- Payne, Devon: PhD, Fields
- Pettygrove, Brian: PhD, Stewart

- 7 F Arnold, Adrienne: PhD, Carlson
- Camilleri, Laura: PhD, Fields
- Corredor-Arias, Luisa: PhD, Fields
- Goemann, Hannah: PhD, Peyton
- Moll, Karen: PhD, Peyton
- Schweitzer, Hannah: PhD, Fields
- Zelaya, Anna: PhD, Fields

### TOTALS

**Total Grads:** 49

- Total MS: 14 9 M / 5 F
- Total PhD: 35 21 M / 14 F

Total Male: 30
Total Female: 19
EDUCATION:

Graduating with advanced degrees: June 2018–June 2019

Jennifer Summers, MS, Chemical and Biological Engineering, December 2018
The development and validation of a standard In vitro method to evaluate the efficacy of surface modified urinary catheters

Barkan Sidar, PhD, Chemical and Biological Engineering, March 2019
Gastrointestinal organoid structure and transport

Anna Zelaya, PhD, Microbiology and Immunology, April 2019
Bacterial Community Dynamics and Variability in Shallow Aquifers

Jeffrey Simkins, PhD, Chemical and Biological Engineering, April 2019
Spatiotemporal Mapping of Oxygen in Model Porous Media Biofilms Using $^{19}$F Nuclear Magnetic Resonance Oximetry

Hannah Schweitzer, PhD, Microbiology and Immunology, April 2019
Bacterial and Archaeal Community Dynamics in Relation to Organic Consumption and Sulfate Gradients in the Powder River Basin

Laura Camilleri, PhD, Microbiology and Immunology, April 2019
Metabolic interactions and activity partitioning in a methanogenic, interdomain biofilm

Zachary Frieling, MS, Chemical and Biological Engineering, May 2019
Urease immobilization for advancing enzyme-induced calcium carbonate precipitation applications

Back to Table of Contents
EDUCATION:

Student News and Awards

**CBE undergrad discusses her ‘chickensplash’ research in radio interview**
If you’re someone who bucks the FDA recommendation of not rinsing raw chicken before cooking it, you might at least want to consider thwarting the advisory with as little risk to human health as possible. Cati Carmody, an MSU junior and CBE researcher, recently told Bozeman radio station KGVM (95.9 FM) that rinsing raw chicken in a bowl prefilled with water can help avoid spreading harmful microbes to nearby surfaces – such as countertops, plates and utensils, and other foods – through airborne water droplets she calls “chickensplash.” The junior mechanical and industrial engineering major recently featured her research in a scientific poster titled “Chickensplash! Exploring the health concerns of washing raw chicken.” [Listen to Cati’s insightful interview.](#)

Volunteering leads to friendship for CBE student
Bekah Anderson, a CBE undergrad in chemical and biological engineering, sought a meaningful use of her time outside of college life. What she found was a new friend – a retired piano teacher living at a care facility. [Read about Bekah’s experience with the non-profit Befrienders in the Bozeman Daily Chronicle.](#)

CBE researchers, lab featured in women in engineering commercial
An advertisement highlighting MSU’s efforts to increase the number of women in the male-dominated fields of engineering and computer science features four female CBE-affiliated faculty members and a student researcher from the CBE. The 60-second advertisement also features one of CBE’s labs. MSU News article: [“MSU releases TV ad featuring women in engineering”](#)
Video: [“Think Outside Expectations: MSU's Women in Engineering”](#)

In the Media
CBE PhD Student Jeffrey Simkins, chemical and biological engineering, earned the cover image and feature article in the August 2018 issue of the *Journal of Magnetic Resonance*. The article details a study that pioneers a new, MRI-based technique for the measurement of oxygen distribution in biofilms which exploits the sensitivity of fluorocarbons to local oxygen concentration. Oxygen gradients are a critical determinant of biofilm behavior, regardless of whether the context is medical, industrial, or environmental, but they are notoriously difficult to measure using conventional approaches. The MRI method is both noninvasive and allows for measurement of oxygen distribution in multiple dimensions simultaneously, and these unique advantages allow novel insights to be made about bacterial oxygen usage under different conditions. Read the article in the August issue of *Journal of Magnetic Resonance, August 2018; 293:123–133.*

Two CBE PhD students collaborate on polymer research
Two PhD students working in separate labs at the CBE traveled to Germany to gain insights into nontoxic substances for potential use in their research projects involving living microbes. [Read more](#)

High school intern tackles limitations of algae as a biofuel
In February, Emily Gan, 17, was reading a publication dedicated to biofuels. When she wanted to learn more about a particular strain of algae used in research at the Center for Biofilm Engineering, she called up the lead author of the study cited in the industry publication. [Read more](#)
CBE Student Awards

CBE PhD student takes top prize in chemical engineering competition
Shawna Pratt, a PhD student in chemical engineering in Montana State University’s Center for Biofilm Engineering, won first place in the Graduate Student Competition in the Microbes at Biomedical Interfaces session at the American Institute for Chemical Engineering’s annual meeting held in Pittsburgh Oct. 28–Nov. 2, 2018. Her 20-minute presentation, titled “Just to Watch You Grow,” focused on her collaborative work on *Pseudomonas aeruginosa* biofilms in the laboratories of CBE faculty Connie Chang, an assistant professor in chemical and biological engineering, and Michael Franklin, a professor in microbiology and immunology. Read more about Pratt’s research

CBE undergrads receive honors, spotlight on research
Bekah Anderson, Honors College undergraduate student in chemical and biological engineering, won the Outstanding Poster Award at the Western Region Honors Conference held on MSU’s campus March 29–31. Bekah presented “Characterization of microplastics in precipitation,” at the annual conference that promotes the advancement of undergraduate honors education. Bekah also received an Honorable Mention at the National Council of Undergraduate Research (NCUR) Posters on the Hill event and participated at the NCUR National Conference held April 10–13 in Atlanta, Georgia.

Nada Naser, undergraduate scholar in chemical and biological engineering, also participated in the NCUR National Conference earlier this month. Nada was invited to deliver a platform presentation of her research “Visualization of microbially induced calcium carbonate precipitation on the single-cell scale using droplet-based microfluidics.”

CBE PhD student earns Judges Prize at Three Minute Thesis competition
Reha Abbasi, MSU PhD student in chemical and biological engineering, earned the Judges Prize for his presentation “3D printing of microorganisms for a better future,” during the Three Minute Thesis competition held on MSU’s campus February 28. Reha has worked at the CBE for three years under the supervision of Dr. Jim Wilking. His research focuses on developing new ways of structuring microbial biofilms in three dimensions using stereolithography-based 3D printers.

For a fifth straight year, graduate students from Montana State University gave the public a chance to hear an 80,000-word thesis distilled into 180 seconds. MSU hosted the Three Minute Thesis event at Inspiration Hall in the Norm Asbjornson College of Engineering building.

The seven finalists chosen for the Three Minute Thesis competition are from disciplines across MSU’s College of Engineering. The finalists explained, very concisely, how their research might affect the public. Presenters were required to condense their research into a brief, engaging presentation for a non-specialist audience, using a single presentation slide.

College of Engineering Awards
MSU-CBE PhD students Matt Jackson and Geoff Zath, both in chemical and biological engineering, were awarded the Raymond E. and Erin S. Schultz Emerging Fellows Award at the department’s banquet held at MSU on April 23. The award is given to chemical and biological engineering graduate students in recognition of their high academic performance in coursework and grades, and history of receiving awards, grants, and scholarships. The award also recognizes research accomplishments evidenced by publications and presentations. Jackson and Zath will split the $18,000 award, using it to fund their research. Jackson’s work focuses optimizing algae
nutrients for bioproduct synthesis and wastewater remediation. Zath is investigating cell diversity of the flu virus using drop-based microfluidics.

**2019 W.G. Characklis Outstanding Graduate Student Award**

CBE awarded the 2019 W.G Characklis Outstanding Graduate Student Award to Ms. Neerja Zambare, PhD candidate in chemical and biological engineering. Neerja was recognized for the quality and productivity of her work at the CBE, especially in the field of biomineralization. She has demonstrated a true passion for biofilm research, which has fueled her drive to overcome any barriers to advance the science. Neerja was also recognized for her exceptional leadership skills and active participation on numerous committees at the CBE, MSU, and professional organizations.

The W.G. Characklis Award is presented annually to CBE doctoral students for their contributions to research and education. The award honors Center Founder Bill Characklis, who envisioned students working in interdisciplinary teams, participating in innovative educational programs, interacting with industry, and assuming leadership roles.

**CBE Student Lab Citizen Award**

George Platt, masters student in chemical and biological engineering, received CBE's Student Lab Citizen Award. Platt was recognized for of his outstanding work in the Fields Lab, as well as his willingness to help others troubleshoot instruments and data analysis, especially with gas chromatography. The CBE also commended Platt’s volunteer efforts, including serving as a 2018-19 committee member of the CBE Seminar Series. Platt’s willingness to get on board with shenanigans was also appreciated, including the 90-degree day you wore hockey breezers to play in the CBE kickball tournament.

The Student Lab Citizen Award is open to any CBE student and recognizes a student’s exceptional responsibility and good citizenship in his or her work at the CBE. Attributes that are considered in selecting awardees include: attention to laboratory safety and cleanliness, considerate use of shared spaces, respect for equipment and proper protocols, willingness to help fellow students and staff, strong work ethic, and commitment to CBE goals. The award is presented in honor of John Neuman, the CBE's Technical Operations Manager from 1994–2008 and was established by John’s family after his death in 2011.

**2019 MSU Student Research Celebration: CBE Participants**

MSU’s undergraduate and graduate students shared their research at the annual Student Research Celebration Thursday, April 18, 2019. Among the more than 200 students presenting their research, numerous students were connected with the Center for Biofilm Engineering.

**POSTERS**

**Tillie Stewart:** Microbiology & Immunology  
Mentors: Ellen Lauchnor, Margaret Eggers – Civil Engineering, Microbiology & Immunology, Center for Biofilm Engineering  
“Characterization of Arsenic Distribution on the Crow Reservation”

**Bekah Anderson:** Chemical & Biological Engineering  
Mentors: Christine Foreman, Markus Dieser – Chemical & Biological Engineering, Center for Biofilm Engineering  
“Characterization of Microplastics in Precipitation”

**Petria Russell:** Chemical & Biological Engineering  
Mentor: Connie Chang – Chemical & Biological Engineering, Center for Biofilm Engineering  
“Encapsulation of Single Bacterial Cells in Alginate Hydrogels”
Anna Martinson: Chemical & Biological Engineering
Mentors: Adrienne Phillips, Arda Akyel – Civil Engineering, Chemical & Biological Engineering, Center for Biofilm Engineering
“pH Controlled UICP”

Mary Burr: Civil Engineering
Mentor: Ellen Lauchnor – Civil Engineering, Center for Biofilm Engineering
“Characterizing Unique Methanotrophs from the Deep Subsurface”

Jacob Rotert: Chemical & Biological Engineering
Mentors: James Wilking, Phil Stewart – Chemical & Biological Engineering, Center for Biofilm Engineering “Fabrication of Custom Microfluidics for Biofilm Investigation in Crevices”

Nickolas Avila: Chemical & Biological Engineering
Mentor: Robin Gerlach – Chemical & Biological Engineering, Center for Biofilm Engineering
“A model to quantify the enhanced mass transfer of CO2 into high alkalinity algae culture medium”

Martina Du: Chemical & Biological Engineering
Mentor: Ross Carlson – Chemical & Biological Engineering, Center for Biofilm Engineering
“Applying Synthetic Biology Techniques to Engineer Microbial Ecology Systems”

Christian Lewis: Chemical & Biological Engineering
Mentor: Brent Peyton – Chemical & Biological Engineering, Center for Biofilm Engineering
“Nutrient-induced accelerated growth of microalgae”

Whitney Kieffer: Chemical & Biological Engineering
Mentor: Ellen Lauchnor – Civil Engineering, Center for Biofilm Engineering
“Remediation of mine tailings using microbially induced calcite precipitation”

Caitlin Carmody: Mechanical & Industrial Engineering
Mentors: Jim Wilking, Scott McCalla – Chemical & Biological Engineering, Mathematical Sciences, Center for Biofilm Engineering
“Chickensplash! Exploring the Health Concerns of Washing Raw Chicken”
**EDUCATION:**

**CBE Seminar Series: Fall 2018**  
Montana State University, Roberts Hall, 321 4:10 p.m.

<table>
<thead>
<tr>
<th>Date</th>
<th>Speaker</th>
<th>Affiliation</th>
<th>Title/Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug 30</td>
<td>Karen Maegaard</td>
<td>PhD Student, Section of Microbiology, Aarhus University, Denmark</td>
<td>Application of H₂ microsensors in environments ranging from microbial mats to anaerobic digesters</td>
</tr>
<tr>
<td>Sept 6</td>
<td>Neerja Zambare</td>
<td>PhD Student, Dept. of Chemical &amp; Biological Engineering, MSU, CBE</td>
<td>Multi-scale microscopy of microbially induced calcium carbonate precipitation</td>
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<tr>
<td>Sept 13</td>
<td>No Seminar</td>
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<tr>
<td>Sept 20</td>
<td>Dr. Mike Franklin</td>
<td>Professor, Dept. of Microbiology &amp; Immunology, MSU, CBE</td>
<td>Ribosome hibernation in dormant <em>Pseudomonas aeruginosa</em> biofilm cells</td>
</tr>
<tr>
<td></td>
<td>Brian Pettygrove</td>
<td>PhD Student, Dept. of Microbiology &amp; Immunology, MSU, CBE</td>
<td>Neutrophil clearance of nascent <em>Staphylococcus aureus</em> biofilm</td>
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<tr>
<td>Sept 27</td>
<td>Dr. Seth Pincus</td>
<td>Professor, Dept. of Chemistry &amp; Biochemistry, MSU</td>
<td>Can HIV infection be cured?</td>
</tr>
<tr>
<td>Oct 4</td>
<td>No Seminar</td>
<td></td>
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<tr>
<td>Oct 11</td>
<td>Dr. Ross Carlson</td>
<td>Professor, Dept. of Chemical &amp; Biological Engineering, MSU, CBE</td>
<td>Multiscale analysis of resource allocation in chronic wound biofilms</td>
</tr>
<tr>
<td>Oct 18</td>
<td>Dr. Carl Yeoman</td>
<td>Associate Professor, Dept. of Animal &amp; Range Sciences, MSU</td>
<td>Unraveling the role of biogenic amines in vaginal dysbiosis and disease</td>
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<tr>
<td>Oct 25</td>
<td>No Seminar</td>
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<tr>
<td>Nov 1</td>
<td>Dr. Diane Bimczok</td>
<td>Assistant Professor, Dept. of Microbiology &amp; Immunology, MSU</td>
<td>How gastric epithelial cells control the immune response to <em>H. pylori</em> infection</td>
</tr>
<tr>
<td>Nov 8</td>
<td>Dr. Alexander Hoover</td>
<td>Assistant Professor, Dept. of Mathematics, University of Akron, Akron, OH</td>
<td>Modeling microbial swimming and interactions in viscoelastic environments</td>
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<tr>
<td>Nov 15</td>
<td>No Seminar</td>
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<tr>
<td>Nov 22</td>
<td>No Seminar- Thanksgiving Day</td>
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<tr>
<td>Nov 29</td>
<td>Dr. Amy Mathers</td>
<td>Associate Professor, Medicine &amp; Pathology, Div. of Infectious Diseases &amp; Int'l. Health, University of Virginia School of Medicine, Charlottesville, VA</td>
<td>Down the drain: The exploration of multidrug resistant bacteria in hospital plumbing</td>
</tr>
<tr>
<td>Dec 6</td>
<td>No Seminar- Last Week of Classes</td>
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</table>
**EDUCATION:**

**CBE Seminar Series: Spring 2019**

**Montana State University, Roberts Hall 301, 4:10pm**

<table>
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<th>Date</th>
<th>Speaker</th>
<th>Affiliation</th>
<th>Title/Topic</th>
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<tr>
<td>Jan 10</td>
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<td>No Seminar</td>
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<td>Jan 17</td>
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<td>No Seminar</td>
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<tr>
<td>Jan 24</td>
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<td>No Seminar</td>
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<tr>
<td>Jan 31</td>
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<td>No Seminar</td>
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</tr>
<tr>
<td>Feb 7</td>
<td>Dr. Sreekala Bajwa</td>
<td>Vice President, Agriculture, MSU</td>
<td>Value addition to agriculture through bio-based products</td>
</tr>
<tr>
<td>Feb 14</td>
<td>Dr. Garth James</td>
<td>Assoc. Research Professor, Chemical &amp; Biological Engineering, MSU; PI, Medical Biofilms Laboratory, CBE</td>
<td>Influence of breast implant textures on bacterial attachment and biofilm formation</td>
</tr>
<tr>
<td>Feb 21</td>
<td>Anna Zelaya</td>
<td>PhD Student, Microbiology &amp; Immunology, MSU, CBE</td>
<td>Microbial community assembly processes in an uncontaminated subsurface aquifer</td>
</tr>
<tr>
<td>Feb 28</td>
<td></td>
<td>No seminar - 3-Minute Thesis Competition</td>
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<tr>
<td>Mar 1</td>
<td>Dr. Mark Lund</td>
<td>Associate Professor, Environmental Management, Edith Cowan University, Joondalup, Western Australia</td>
<td>Using microbial assemblages as part of an environmental assessment of a mine pit lake closure using a river flow-through</td>
</tr>
<tr>
<td>Mar 5</td>
<td>Dr. Jennifer Macalady</td>
<td>Professor, Geosciences, Pennsylvania State University, State College, PA</td>
<td>Frasassi dark and deep: A biofilm factory in the terrestrial subsurface</td>
</tr>
<tr>
<td>Mar 7</td>
<td>Dr. Kara De Leon</td>
<td>Postdoctoral Research Fellow, University of Missouri, Colombia, MO</td>
<td>Genetic requirements for <em>Desulfovibrio vulgaris Hildenborough</em> biofilm formation in bioreactors and the rat colon</td>
</tr>
<tr>
<td>Mar 14</td>
<td>Dr. Chelsea Heveran</td>
<td>Assistant Professor, Mechanical and Industrial Engineering, MSU</td>
<td>Bone-inspired design of tough infrastructure materials</td>
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<tr>
<td>Mar 21</td>
<td></td>
<td>No Seminar- Spring Break</td>
<td></td>
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<tr>
<td>Mar 28</td>
<td>Stephanie Dodson</td>
<td>PhD Student, Applied Mathematics, Brown University, Providence, RI</td>
<td>Geometry dependent instabilities of waves in excitable media</td>
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<tr>
<td>Apr 4</td>
<td>Dr. Roland Hatzenpichler</td>
<td>Assistant Professor, Chemistry &amp; Biochemistry, MSU, CBE</td>
<td>A new Confocal Raman microscope with cell-sorting ability at MSU: What to do with it and how to get seed funding for using it</td>
</tr>
<tr>
<td>Apr 11</td>
<td>Undergraduate Research Day</td>
<td>Cati Carmody, Chemical &amp; Biological Engineering, MSU, CBE</td>
<td>Chickensplash! Exploring the health concerns of washing raw chicken</td>
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<tr>
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<td></td>
<td>Whitney Kieffer, Chemical &amp; Biological Engineering, MSU, CBE</td>
<td>Bacterially influenced leaching of metals from mine tailings</td>
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<tr>
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<td></td>
<td>Nick Avila, Chemical &amp; Biological Engineering, MSU, CBE</td>
<td>A model to quantify the enhanced mass transfer of CO2 into high alkalinity algae culture medium</td>
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<tr>
<td>Apr 18</td>
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<td>No Seminar</td>
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<tr>
<td>Apr 26</td>
<td></td>
<td>No Seminar- Last Week of Classes</td>
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TECHNOLOGY TRANSFER:
Industrial Associates, 2018–19
Bold, new  *Small business member

3M
Accuratus Lab Services*
American Chemet*
ASP
BASF
Baxter Healthcare
Boston Scientific Urology
Chem-Aqua
Church & Dwight Company
Clorox
Decon7 Systems*
DeLaval
Dow Microbial Control
Ecolab
ICU Medical, Inc.
Lonza
Masco Corporation
Medentech
Next Science
Olympus
PPG Industries
Procter & Gamble Company
PureLine Systems*
SANUWAVE Health*
SC Johnson
Sharklet Technologies*
Smith & Nephew
Solvay
Sterilex*
STERIS
The Sherwin-Williams Company
Zimmer Biomet
TECHNOLOGY TRANSFER:
Montana Biofilm Meeting
July 17–19, 2018

Monday
July 16
6:00–8:30 pm
Registration & welcome reception
Larkspur Foyer, Hilton Garden Inn
Bozeman

Tuesday
July 17
7:30–8:00 am
Registration & continental breakfast
Larkspur Foyer, Hilton Garden Inn

8:00–8:10
Introductory remarks, Larkspur Ballroom
Matthew Fields, CBE Director
Paul Sturman, CBE Industrial Coord.
Laura Wahlen, Research Scientist,
Baxter Healthcare, Round Lake, IL

SESSION 1:
Biofilm Methods
8:10–8:35
Biofilm removal and control issues in food processing: Biofilm reactor and drain models
Charles Giambrone, Vice President,
Technical Services, Rochester Midland Corp., Rochester, NY

9:35–10:05
Networking Break

10:05–10:30
Shear stress mediates metabolism and growth in electroactive biofilms
Andrew Jones, Postdoctoral Researcher, Mechanical & Industrial Eng., Northeastern University, Boston, MA; CBE Young Investigator Awardee

10:30–11:00
The versatility of shockwaves in destroying biofilms
Iulian Cioanta, Vice President,
Research & Development,
SANUWAVE Health, Suwanee, GA

SESSION 2:
Bacteriophage and Biofilm
11:00–11:30
A bacteriophage integrase regulates virulence factor production by Pseudomonas aeruginosa
Pat Secor, Assistant Professor,
Biological Sciences, University of Montana; CBE Young Investigator Awardee

11:30–12:00
A potential biocontrol strategy for healthcare facilities using a surfactant-supplemented bacteriophage cocktail for the control of carbapenemase-producing Klebsiella pneumoniae biofilms
Ariel Santiago, ORISE Research Fellow, Biofilm Laboratory, Centers for Disease Control, Atlanta, GA; CBE Young Investigator Awardee

12:00–1:00 pm
Catered lunch, Hilton Garden Inn

Special Presentation:
1:00–1:30
Life in the human gut microbiome
Seth Walk, Assistant Professor,
Microbiology & Immunology, MSU

SESSION 3:
Strategic Communication and Data Resources
1:30–2:00
BRaID: Biofilm data fusion
Dave Millman, Assistant Professor,
Gianforte School of Computing, MSU

2:00–2:30
Fostering a common vision to mobilize innovation across government, industry and academic partnerships
Jayne Morrow, Sr. Science Policy Advisor, NIST, Gaithersburg, MD

CBE Open House:
Poster session and lab demonstrations
3:00–5:00
3rd Floor Barnard Hall, MSU
Schedule available onsite

Wednesday
July 18
7:30–8:00 am
Registration & continental breakfast
Larkspur Foyer, Hilton Garden Inn

SESSION 4:
Medical Biofilms
8:00–8:05
Session introduction
Garth James, Associate Research Professor, Chem. & Biological Eng., MSU; PI, Medical Biofilms Laboratory, CBE
8:05–8:15  
Clinical efficacy of biofilm disruption technology developed with testing at the CBE  
Alicia Tetlak, Microbiologist, Next Science LLC, Jacksonville, FL

8:15–8:45  
Diabetic wound care in our veteran population  
MaryCloud Ammons Anderson, Research Scientist, Idaho Veterans Research and Education Foundation, Boise VA Medical Center, Boise, ID

8:45–9:15  
How bacteria in biofilms withstand antibiotics  
Phil Stewart, Distinguished Professor, Chem & Bio. Eng., MSU, CBE

9:15–9:45  
Microplate hydrogel assay for antibiofilm testing  
Kenneth Scott Phillips, Biofilms Research Group Leader, Center for Devices & Radiological Health, US FDA, Silver Spring, MD

9:45–10:15  Networking Break

10:15–10:45  
Biofilm: The clinical dilemma  
Eric Johnson, MD, Bozeman Health Wound and Hyperbaric Center, Bozeman, MT

10:45–11:15  
Characterization of Mycobacterium chimaera biofilms on medical device materials  
Archana Siddam, Commissioner's Fellow, Winchester Engineering & Analytical Center, US FDA, Winchester, MA

11:15–11:45  
Design, synthesis, and evaluation of prodrug antimicrobials to control biofilms  
Danica Walsh, PhD Student, Chemistry & Biochemistry, MSU, CBE

11:05–12:00  
Presentation of CBE awards  
Matthew Fields

12:00–1:00 pm  
Catered lunch, Hilton Garden Inn

SESSION 5:  
Biofilm Physiology

1:00–1:30  
Investigating single cell growth using drop-based microfluidic incubation  
Shawna Pratt, PhD Student, Chemical & Biological Engineering, MSU, CBE

1:30–2:00  
Heterogeneity in Pseudomonas aeruginosa populations  
Tatsuya Akiyama, Postdoctoral Researcher, Microbiology & Immunology, MSU

2:00–2:30  
Spatiotemporal mapping of oxygen in a microbially-impacted packed bed using 19F nuclear magnetic resonance oximetry  
Jeffrey Simkins, PhD Student, Chemical & Biological Engineering, MSU, CBE

2:30–3:00  
CRISPR-mediated defense and bacteriophage counter-defense in P. aeruginosa  
MaryClare Rollins, Research Associate, Microbiology & Immunology, MSU

3:00–3:15  
State of the CBE Address  
Matthew Fields

3:30–5:00  
Business Meeting  
Hilton Garden Inn

Thursday  
July 19

7:30–8:00 am  
Registration & continental breakfast  
Larkspur Foyer, Hilton Garden Inn

SESSION 6:  
Biofilm Imaging

8:00–8:30  
CBE imaging capabilities: An overview  
Heidi Smith, Postdoctoral Researcher, CBE

8:30–9:00  
Quantification of biofilm characteristics from images with error bars  
Al Parker, Biostatistician, CBE; Assistant Research Professor, Mathematical Sciences, MSU

9:00–9:30  
Characterizing biofilms using centrifuge force microscopy  
Tom LeFevre, PhD Student, Chem. & Bio. Eng., MSU, CBE

9:30–10:00  Networking Break

SESSION 7:  
Industrial Biofilms

10:00–10:30  
Biofilms in industrial water handling systems: An overview of real-time biomonitoring and system performance  
David Vela, Senior Research Scientist; Angela Delegard, Research Scientist, Chem-Aqua, Irving, TX

10:30–11:00  
Microbial defacement of building materials  
Erika Espinosa-Ortiz, Postdoctoral Researcher, CBE

11:00–11:30  
Scale in water systems: A biomineral?  
Adrienne Phillips, Assistant Professor, Civil Eng., MSU, CBE

11:30–11:40  
Meeting wrap up
**WORKSHOP:**

**A Two-Part MBM Advanced Biofilms Workshop**  
July 16, 2018

**Part I: Imaging Biofilms with Optical Coherence Tomography (OCT)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Presenter(s)</th>
<th>Location</th>
</tr>
</thead>
</table>
| 8:00 – 8:15 | Welcome – *Matthew Fields, CBE Director*  
Group introductions | 323 BH                      | 323 BH    |
| 8:15 – 8:30 | An overview to today’s workshop – *Paul Sturman* | 323 BH                      | 323 BH    |
| 8:30 – 9:30 | Imaging biofilms with OCT – *Jim Wilking* | 323 BH                      | 323 BH    |
| 9:30 – 9:45 | *Morning Refreshments* | 323 BH                      | 323 BH    |
| 9:45 – 11:50 | *Hands-On! OCT Training* – *Jim Wilking* | TBD BH                      | TBD BH    |
| 11:50 - 12:00 | Group Photos  
Outside (weather permitting) | 134 BH                      | 134 BH    |
| 12:00 - 1:15 | LUNCH | 407 JABS | 407 JABS |

**Part II: Developing Ontology for Biofilm Researchers**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Presenter(s)</th>
<th>Location</th>
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<tr>
<td>1:15 – 2:00</td>
<td>An introduction to BRaID – <em>Thiru Ramaraj</em></td>
<td>323 BH</td>
<td>323 BH</td>
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<tr>
<td>2:00 - 2:15</td>
<td><em>Afternoon Refreshments</em></td>
<td>134 BH</td>
<td>134 BH</td>
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<tr>
<td>2:15 – 4:30</td>
<td><em>Hands-On! Protégé orientation</em> – <em>Thiru Ramaraj &amp; Karen Moll</em></td>
<td>134 BH</td>
<td>134 BH</td>
</tr>
<tr>
<td>4:30 – 5:00</td>
<td>Wrap-Up/Discussion</td>
<td>323 BH</td>
<td>323 BH</td>
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TECHNOLOGY TRANSFER:
Biofilm Technologies: Pathways to Product Development
February 5-6, 2019 Arlington, VA

Tuesday
February 5
7:30-8:00 am
Registration & Cont. Breakfast, Commonwealth Foyer
Meeting, Williamsburg/Yorktown Ballroom

8:00–8:15 am
Introductory remarks
Matthew Fields, CBE Director
Paul Sturman, CBE Industrial Coord.

Keynote
8:15-8:50 am
Biofilm tolerance favors rapid emergence of antibiotic resistance
Christophe Beloin, Associate Professor; Co-Director, Institut Pasteur Microbiology Course, Institut Pasteur

SESSION 1
Food-Related Biofilms
8:50-9:25 am
Biofilms in beer
Diane Walker, Research Engineer, CBE

9:25-10:00 am
Trending topics in food protection: A review from the 2018 food conferences
Diane Walker

10:00-10:30 am
Break

10:30-11:05 am
Biofilms, sanitizers, and meat safety
Rong Wang, Research Microbiologist, Meat Safety & Quality Research, US Meat Animal Research Center

11:05-11:40 am
Biofilm management in food and beverage processing
Erin Mertz, Area Technical Support Coordinator, Food & Beverage, Ecolab

12:00–1:00 pm
Lunch, Richmond/Roanoke

SESSION 2
Biofilm Detection
1:00-1:30 pm
Tracking antimicrobial resistance from sink drain biofilms
Amy Mathers, MD, Associate Director, Clinical Microbiology, University of Virginia

1:30-2:00 pm
Different techniques to visualize, quantify, and investigate biofilms
Matthew Fields

2:00-2:30 pm
Electrochemical sensing of quorum sensing molecules and virulence factors
Edgar Goluch, Associate Professor, Chemical Engineering, Northeastern University

2:30-3:00 pm
Break
Sponsored by Decon7 Systems

SESSION 3
Antimicrobials and Regulation
3:00-3:30 pm
Global regulatory impediments and their effect on trade
Adrian Krygsman, Director, Troy Corporation

3:30-4:00 pm
Biofilm claims and product development
Dan Klein, Senior Manager, R&D Microbiology, STERIS Corporation

4:00-4:30 pm
Antimicrobial pesticides: Regulatory update and methods development initiatives
Steve Tomasino, Senior Scientist, Office of Pesticide Programs, US EPA

Wednesday
February 6
7:30-8:00 am
Continental Breakfast, Richmond/Roanoke
Meeting, Williamsburg/Yorktown Ballroom

SESSION 4
Breast Implant Biofilms
8:00-8:05 am
Session Introduction
Garth James, Associate Research Professor, Chemical & Biological Engineering, MSU; PI, Medical Biofilms Laboratory, CBE

8:05–8:40 am
Controversies in biofilm and breast implants
Roger Wixtrom, President, LSCI

8:40–9:10 am
Influence of breast implant textures on bacterial attachment and biofilm formation
Garth James, Associate Research Professor, Chemical & Biological Engineering, MSU; PI, Medical Biofilms Laboratory, CBE

9:10–9:45 am
Mechanical factors that may contribute to the involvement of surface texture on the pathogenesis of soft tissue implant associated complications
Hainsworth Shin, Fellow, Biomedical Engineer, Center for Device & Radiological Health, US FDA
9:45-10:15 am
Breast implant surface texture impacts tissue response
TracyAnn Perry, Vice President, Science & Research, Establishment Labs

10:15-10:45 am
Break

SESSION 5
Medical Device
Cleaning/Reprocessing
10:45-11:00 am
Reusable medical devices: Understanding the challenges and presenting a path forward
Paul Sturman

11:00-11:35 am
Overview of biofilms in flexible endoscopes
Kaumudi Kulkarni, R&D Manager, Healthmark Industries Company

11:35-12:10 pm
Fluorescence microscopy-based SOP for detecting cellular contamination of endoscopes
Scott Phillips, Regulatory Research Scientist, Center for Device & Radiological Health, US FDA

12:10 pm–1:10 pm
Lunch, Richmond/Roanoke

1:10-1:45 pm
Growth of *Mycobacterium chimaera* in heater-coolers
Joe Falkinham, Professor, Microbiology, Virginia Technological Institute

1:45-2:15 pm
Ultrasound device disinfection: A patient safety risk
Marcia Ryder, Research Scientist, Ryder Science, Inc.

2:15-2:45 pm

Round Table Discussion
TECHNOLOGY TRANSFER:

NEWS HIGHLIGHTS

STERIS earns first biofilm claim from EPA using testing standard developed by CBE
An Industrial Associate of the Center for Biofilm Engineering received the first biofilm claim to be authorized under U.S. EPA regulations using Method MB-19 and/or MB-20 (dated July 2017). Ohio-based STERIS Corporation earned the claim for its ProKlenz® ONE alkaline detergent in July 2018. The CBE was part of the team that developed the standard testing method that the U.S. EPA requires products meet or exceed for the company to use the biofilm claim in the marketing of the product. Since its founding at Montana State University in 1990, the CBE has worked closely with private and governmental agencies through its membership-based Industrial Associates Program. Please see STERIS Corporation’s press release for more information about earning the country’s first biofilm removal claim.

CBE welcomed new members to its Industrial Associates Program:

**Advanced Sterilization Products** (ASP) is a Johnson & Johnson company that makes a variety of sterilization and high-level disinfection products. They’re a leader in infection prevention, helping facilities prevent healthcare-associated infections by designing and delivering best-in-class medical device processing products and equipment. Keyvan Nowruzi is the CBE designated representative.

**Clorox** has been bringing the cleaning and disinfecting power of bleach to the world for almost 100 years. Today, an estimated eight out of ten American households use Clorox brand bleach. Clorox brand laundry and home cleaning products are sold in more than 100 countries in North America, South America, Europe, Africa, and Asia. This cleaning agent, derived almost 100 years ago from a salt pond in the San Francisco area, is now a cleaning essential used in homes throughout the world. Bill King is the CBE designated representative.

**Olympus** is a Japanese manufacturer of optics and reprography products. It was established in 1919, initially specializing in microscopes and thermometers. Today, Olympus holds roughly a 70-percent share of the global endoscope market. Their medical business division works with healthcare professionals delivering the diagnostic and therapeutic technologies they need to treat their patients. Jason Ashraf, director of reprocessing strategy, will be the CBE designated representative.

**PureLine Systems** specializes in the generation and application of chlorine dioxide aimed at improving the quality of water supplies used in “various markets, including oil and gas production, municipal water, hospital and healthcare facility secondary disinfection, food and beverage, district energy, and manufacturing industries.” Established in 1995 as ElectroSci, the company expanded three years later and changed its name to PureLine. Bob Sullivan is the designated representative to the CBE.

Founded in 1886, **S.C. Johnson** is a family-owned company and one of the world’s leading producers of household brands. Their product portfolio is vast and includes global brands that help every household with cleaning, pest control, storage, shoe and auto care, and home fragrance.

CBE Industrial Associates
CBE membership

**CBE launches third methods training video**
CBE, in collaboration with MSU’s Department of Visual Media and BioSurface Technologies, launched the Single Tube Method training video. It covers ASTM Method E2871, disinfection and neutralization, and biofilm removal and disaggregation. The video also provides a link to calculate log reduction and helpful tips on conical vials, splash guards, neutralization, sonication, and filtration. View all of the methods training videos.
**NASA seeks ideas for biofilm problem**
The International Space Station has a biofilm problem in its wastewater plumbing. Biofilm can grow in the water recycling system, and while it poses no immediate threat to the astronaut scientists orbiting some 220 miles above earth, it’s a problem that needs a solution nonetheless. Without one, NASA’s biofilm problem is sure to follow tomorrow’s astronauts on missions to the moon, Mars, and possibly other destinations where maintenance shuttles will be impractical to come by.

In the same week as the 50th anniversary of man first walking on the moon, NASA engineers convened in Bozeman to brainstorm potential solutions with scientists from the Center for Biofilm Engineering and attendees of its Montana Biofilm Meeting shortly after the annual meeting wrapped up July 18.

“We plan to use these ideas to design concepts that we’ll develop into a trade study,” says Layne Carter, manager of the water subsystem on the International Space Station. “If it goes as planned, we’ll do a technology demonstration on the ISS. Will that be in two years? Three years? I do not know. But it will be as fast as we can do it.”

Carter also offered a carrot: “There is plenty of opportunity for funding here.”

The wastewater on the ISS is comprised by two primary waste streams: crew urine and humidity condensate from respiration and perspiration, according to information provided by NASA. None of these liquids have a biocide to inhibit microbial growth. As a result, biofilm forms in the wastewater plumbing.

Carter and other NASA personnel briefed the group on the problem and what the solution needs to accomplish. He also stated an obvious — but important — caveat: while the long-term solution for future spaceships will be installed on earth, the solution that will be tested on the ISS needs to be able to be implemented in microgravity.

Ideas discussed in the freeform meeting included biocides, antimicrobial coatings, redesigned storage receptacles, and using the sun’s ultraviolet rays as a disinfectant.

“I’m thrilled by the feedback we’ve gotten from the people in this group,” Carter said. “I’m ecstatic about that.”

**VIDEO: Documentary examines biofilms, CBE**
Biofilms have profoundly shaped the world almost since the dawn of life on earth. These communities of self-organized microbes are remarkably resilient, and they wreak havoc on human health and societal infrastructure every day. Governments and industries in the U.S. alone spend a half-trillion dollars each year fighting biofilm-related corrosion. As this 6-minute documentary shows, researchers at the CBE – the world’s first, largest, and best-known biofilm research center – are on the front lines of this critical battle, seeking real-world solutions to real-world problems by peeling back the mysteries of these fascinating – and devastating – microbial communities. [VIDEO](https://www.youtube.com/watch?v=dQw4w9WgXcQ)

**Bozeman reactor company celebrates 25 years of supporting biofilm research**
CBE congratulates [BioSurface Technologies](https://www.biosurfacetech.com) on 25 years in the business of providing laboratory bioreactors for biofilm study. BioSurface Technologies reactors are used in ASTM biofilm growth and treatment methods, as well as by many academic and industry laboratories around the world. The company is based in Bozeman, Montana.
TECHNOLOGY TRANSFER:

Industry and Agency Interactions

Industry Visits to CBE

Paul Sturman, CBE industrial coordinator, hosted Mason Nagasaki, Takashi Abe, Jason Ashraf, and Takashi Kinebuchi from Olympus. The group met with Darla Goeres and Garth James to discuss projects related to their endoscope division. October 31, 2018

Denis Bendejacq, Richard Jacubinas, and Gilda Lizarraga from Solvay, a CBE industrial member for several years, visited the center to discuss potential projects. November 13, 2018.

Paul Sturman, CBE industrial coordinator, presented “Biofilm growth and response to antimicrobial treatment,” at PureLine System’s technical symposium in Chicago, Illinois. PureLine is a member of the CBE Industrial Associates Program. They specialize in the application of chlorine dioxide to improve the quality of water supplies used in various markets. December 11, 2018

Early this year, Todd Roper and Mike Marotz from Carboceramics visited the CBE to discuss potential testing projects and membership. Carboceramics sells a variety of products and services related to oil and gas industrial processes, and environmental applications. They were hosted by affiliated faculty Robin Gerlach, professor in chemical and biological engineering and Adrienne Phillips, assistant professor in civil engineering. January 22, 2019.

CBE’s Standardized Biofilm Methods Lab (SBML) hosted the following industrial visitors:

- Jillian Vocke and Tyler Zanon from Medline visited the center to learn about the drip flow reactor in preparation for their participation in the ASTM interlaboratory study. February 2019
- Sasha Zavgorodnya from Solvay worked with SBML researchers on a project using a new cooling tower reactor currently in development at BioSurface Technologies. April 2019
- Sailaja Chandrapati from 3M visited the SBML to work on biofilm sampling methods. April 2019

CBE Visits to Industry


Paul Sturman, as an invited speaker presented “Biofilm growth and response to antimicrobial treatment,” at L’Oreal in Newark, New Jersey. Paul was also invited to present a poster “CBE helps industry solve biofilm problems,” at L'Oreal's industry partners poster session. September 12, 2018.

Jim Wilking, assistant professor in chemical & biological engineering, was invited to present at STERIS Corporation’s Scientific Conference October 10–12 in St. Louis, MO. Jim presented “Biofilms as soft materials.” STERIS is a leading provider of infection prevention and other procedural products and services, focusing primarily on healthcare, pharmaceutical and medical device customers. They have been a member of the CBE's Industrial Associates Program since 2011. October 10–12, 2018.
OUTREACH:

News Highlights

**Standardized Biofilm Methods Lab hosting workshop at IAFP Annual Meeting**
The CBE Standardized Biofilm Methods Lab conducted a [workshop](#) at the annual meeting of the International Association for Food Protection in Salt Lake City July 8—11, 2018. The workshop was designed for anyone interested in standard methods, growing relevant biofilms, and those wanting to test surfaces, agents, or fabrics for antimicrobial efficacy against biofilms.

**8th ASM Biofilms Conference**
CBE researchers took an active role at the 8th ASM Conference on Biofilms October 10–11, 2018 in Washington, D.C. Phil Stewart was part of the program committee and served as chair of the session on biofilm antimicrobial tolerance. Mike Franklin, professor in microbiology & immunology, presented “Ribosome hibernation in dormant *Pseudomonas aeruginosa* biofilm cells,” and Brian Pettygrove, PhD student in microbiology & immunology, received a travel award to present his research on neutrophil clearance of nascent *Staphylococcus aureus* biofilm.

CBE's Standardized Biofilm Methods Lab (SBML) was invited to present a workshop on methods for biofilm laboratory studies. The full-day workshop was one of three pre-meeting workshops offered by the conference. It was designed for researchers interested in standard methods, growing relevant biofilms, and testing surfaces, agents, or fabrics for antimicrobial efficacy against biofilms. The SBML also hosted this workshop in July at the International Association for Food Protection meeting in Salt Lake City, UT. Read [workshop abstract](#)

**Nikon High Resolution Imaging Workshop**
CBE hosted Nikon for a presentation on recent advances in high resolution imaging April 19. Technicians from Nikon spoke about hyperspectral imaging, super resolution microscopy, data analysis, and advances in confocal laser scanning microscopy. Instrument demos were also available based on attendee interest. The event was organized by Heidi Smith, CBE Microscopy Facility manager. Heidi assumed the role as head of the million-dollar microscopy facility in September 2018. Read [about the state-of-the-art facility](#)
OUTREACH:

Visiting Researchers

Visiting Faculty

**Bastiaan Krom**, faculty from University of Amsterdam, The Netherlands
Area of study: Oral biofilms, host interactions
CBE host: Garth James, associate research professor, chemical & biological engineering
Visiting June 2018–August 2018

**Ayrat Ziganshin**, faculty from Kazan Federal University, Kazan, Russia
Home department: Microbiology
Area of study: Fungi
CBE host: Robin Gerlach, professor, chemical & biological engineering
Visiting June 2018–September 2018

**Elvira Ziganshin**, faculty from Kazan Federal University, Kazan, Russia
Home department: Microbiology
Area of study: Urinary tract stone formation
CBE host: Robin Gerlach
Visiting June 2018–September 2018

**Nicolas Forquet**, faculty from the National Institute for Environmental and Agricultural Science and Research in Lyon, France
Area of study: Root biofilm interactions in treatment wetlands
CBE host: **Otto Stein**, professor, civil engineering, and **Ellen Lauchnor**, assistant professor, civil engineering
Visiting August 2018–January 2019

**Scott Wade**, associate professor, Swinburne University, Melbourne, Australia
Home department: Telecommunications, Electrical, Robotics, and Biomedical Engineering
Area of study: Corrosion and investigating microbially influenced corrosion (MIC) and the development of new sensing systems.
CBE host: Matthew Fields, CBE director
Visiting July 2019–December 2019

CBE hosted six visiting researchers from the University of Stuttgart, Germany for a week-long biofilm and biomineralization workshop February 25–28, 2019. Visitors included: Dr. **Johannes Hommel**, Felix Weinhardt, Prof. **Holger Class**, Joseph Piotrowski, Prof. **Holger Steeb**, and Dr. **Nikos Karadimitriou**. CBE hosts were **Al Cunningham**, professor emeritus in civil engineering, **Robin Gerlach**, professor in chemical and biological engineering, and **Adie Phillips**, assistant professor in civil engineering.

Visiting Student Researchers

**Lenno van den Berg**, PhD student
Home university: Delft University of Technology, The Netherlands
Area of study: Wastewater treatment
CBE hosts: Sarah Codd, professor, mechanical and industrial engineering; Cat Kirkland, associate research professor, civil engineering
Visiting May 2018–August 2018
Rachel Kleiman, Masters student
Home university: University of North Carolina, Chapel Hill
Area of study: Algal biofuels
CBE host: Robin Gerlach
Visiting June 2018–August 2018

Elizabeth Lee, High School student
Hometown: Bozeman, MT
CBE Project: Growth and use of algae as a biofertilizer
CBE host: Matthew Fields, CBE director; professor, microbiology and immunology
Visiting June 2018–August 2018

Hannah Sylvester, Undergraduate student
Home university: Carroll College, Helena, MT
Area of study: Biology and health sciences
CBE host: Connie Chang, assistant professor, chemical and biological engineering
Visiting May 2018–August 2018

Albert Tafur, PhD student
Home university: Universidad de Los Andes, Bogota, Colombia
Area of study: Metabolic pathways
CBE hosts: Ross Carlson, professor, chemical & biological engineering
Visiting August 2018–November 2018
OUTREACH:

**Web image library use 2018-2019**

Total image downloads: **298**

Requests for CBE graphics were submitted from **29** of the U.S. states:


There were requests from an additional **29** countries:

Argentina  Hungary  Poland  Australia  India  Portugal  Belgium  Indonesia  Qatar  Brazil  Ireland  Serbia  Canada  Italy  South Africa  Chile  Japan  Spain  Denmark  Kazakhstan  Sweden  France  Mexico  Switzerland  Germany  Netherlands  Turkey  Greece  New Zealand  United Kingdom
FACILITIES:

Center for Biofilm Engineering Facilities Overview

Located in Barnard Hall next to the Strand Union Building, the Center for Biofilm Engineering comprises more than 20,000 square feet, and includes offices and conference rooms for faculty, staff, and students; a computer lab; and 13 fully equipped research laboratories. General use areas include an analytical instrument lab, a microbiology lab with media preparation area and autoclaves, and a general molecular area with two thermocyclers, a gel running and imaging station, and spectrophotometers for nucleic acid quantification, as well as an isolated radioactive isotope lab. See below for a comprehensive list of shared equipment available.

Microscope Facilities

The microscopy and chemical imaging 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, fluorescent and Raman confocal microscopy. The microscopy facilities include four separate laboratories—the Optical Microscopy Lab, the Confocal Microscopy Lab, the Chemical Imaging Lab, and the Microscope Resource Room and Digital Imaging Lab—which are detailed below.

- The Optical Microscopy Lab houses two Nikon Eclipse E-800 research microscopes which are used for transmitted light and epi-fluorescent imaging. Both microscopes are equipped with Photometrics MYO cooled CCD cameras and use Universal Imaging Corporation’s MetaVue software (v 7.4.6) for digital image acquisition. We have a large collection of fluorescence filter cubes for the Nikons, including those optimized for the following fluorescent stains: FITC (gfp), TRITC (propidium iodide), DAPI, CTC, ELF-97, CY5, cfp, and we also have a B2E cube. Both Nikons are equipped with Nomarski/DIC, and we have a 100x oil phase contrast objective and condenser especially for use with imaging spores.

Our microscope collection has expanded with the acquisition of a new Leica LMD6 Laser Microdissection System equipped with a color camera, fluorescence filter cubes (FITC, TRITC, DAPI), and a UV laser for sample dissection. Another recent addition is the GAN210 Optical Coherence Tomography (OCT) imaging system. OCT is a high resolution, non-contact, non-invasive, and non-fluorescent based technique that is well suited for imaging thick specimens. The OCT light source centered around 930 nm with a bandwidth >100 nm and has a scan rate of up to 36 kHz with an axial field of view of 2.9 mm / 2.2 mm. Depending on the scan objective the field of view (FOV) and resolution can be adjusted and vary between a larger FOV of 16x16 mm² at 12 µm resolution, and a FOV of 10x10 mm² with a higher resolution of 8 µm.

Additionally, within the Optical Microscopy Lab is a Leica M 205 FA computer-controlled stereomicroscope and a Leica DFC3000G fluorescence camera. This stereoscope can be used to image samples using fluorescence, brightfield with or without polarization or Rotterman contrast, and reflected white light. The software will also allow a z-stack of images to be collected and recomposed using simple deconvolution. Other equipment in the Optical Microscopy Lab includes a Nikon SMZ-1500 barrel zoom stereomicroscope equipped with a color camera, a Leica cryostat, and a dry ice maker.

- The Confocal Microscopy Lab contains two Leica SP5 Confocal Scanning Laser Microscopes (CSLMs). One is an inverted confocal microscope with 405, 488, 561 and 633 nm laser excitation lines. It is equipped with a tandem scanner, so it can be switched from standard scanning mode to operate in Resonant Scanner mode, which enables scanning at exceptionally high frequencies for fluorescent imaging. This faster scanning is necessary for most live cell imaging (note: “live cell imaging” doesn’t generally refer to imaging bacterial cells, but rather mammalian cells and processes). This inverted SP5 also includes a heated stage with an environmental control chamber (i.e. it can be used to provide an enclosed CO₂ atmosphere), and a motorized stage with Mark-and-Find and image tiling capabilities.

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

The CSLM is capable of imaging biofilms on opaque surfaces, so a wide variety of materials can be used in the experimental flow cells. As biofilm formation proceeds in an experiment, representative areas of the colonized surface are scanned with the use of the automatic stage. Digital data is collected from sequential scans, and stored data can be viewed in the x, y, z coordinates to yield a 3-dimensional image of the biofilm architecture. Quantitative and qualitative information about biofilm architecture can be retrieved easily from examination of CSLM data, in both the x-y and x-z planes, and the existence or absence of structural features, such as microcolonies and water channels, can be determined.
- The **Chemical Imaging Lab** contains a Horiba **Confocal Raman Microscope**. Raman is a vibrational spectroscopic method that provides a fingerprint of the molecular, and to some extent the isotopic composition of a sample. The Horiba LabRam HR Evolution NIR is dedicated to studying the molecular composition of a sample. This is a fully integrated high resolution Raman microscope for confocal Raman analysis, optimized for the visible to IR range (400nm-2500nm) microscope. It includes a confocal Raman microscope with an automated xyz-stage with fast-mapping capabilities. transfer optics, stigmatic spectrometer equipped with two gratings (600 and 1800 l/mm gratings), multichannel air-cooled CCD detector, and computer package with the latest version of the LabSpec6 software and the KnowItAll Raman spectra library, Horiba edition. It is equipped with 532nm 100mW laser, HeNe 633nm laser, 785nm 90mW laser, and 10x, 50x, 100x, 20xLWD and 50xLWD objectives.

- 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 computer-intensive data analysis like particle tracking and 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, a server 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.

**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 (GC) 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 have been added as well as an additional Agilent 1100 series high performance liquid chromatography system with autosampler and an Agilent 6890 GC with autosampler and flame ionization detector. The chromatographs and 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.

**Specialized CBE Laboratories**

**Ecology/Physiology Laboratory**

The Ecology/Physiology Laboratory headed by Dr. Matthew Fields has general microbiology equipment, anaerobic gassing stations in two lab spaces, Shimadzu UV-VIS spectrophotometer, Ultra-Centrifuge, Anaerobic Chamber, biofilm reactors, protein and DNA electrophoresis, Qubit fluorometer, two Eppendorf Mastercylcers, incubators, laminar/fume hoods, microcentrifuges, table-top centrifuges, and a microcapillary gas chromatograph with dual TCDs. The lab has two light-cycle controlled photo-incubators as well as photo-bioreactors for the cultivation of algae and diatoms, and maintains two -20°C freezers and three -70°C freezers for sample storage. Additionally, the lab has a large capacity refrigerated incubator (5-70°C) for temperature critical studies.

This laboratory houses an Illumina MiSeq Sequencing System. The MiSeq desktop sequencer allows the user to access more focused applications such as targeted gene sequencing, metagenomics, small genome sequencing, targeted gene expression, amplicon sequencing, and HLA typing. This system enables up to 15 Gb of output with 25 M sequencing reads and 2x300 bp read lengths by utilizing Sequencing by Synthesis (SBS) Technology. A fluorescently labeled reversible terminator is imaged as each dNTP is added, and then cleaved to allow incorporation of the next base. Since all four reversible terminator-bound dNTPs are present during each sequencing cycle, natural competition minimizes incorporation bias. The end result is true base-by-base sequencing that enables the industry’s most accurate data for a broad range of applications. The method virtually eliminates errors and missed calls associated with strings of repeated nucleotides (homopolymers).

**Medical Biofilm Laboratory**
The Medical Biofilm Laboratory (MBL) has earned a reputation for being a university lab that focuses on industrially relevant medical research 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 includes a full-time research professor, three technicians, and one undergraduate research assistant. Currently, twelve companies, including CBE Industrial Associates, sponsor MBL projects. These projects include evaluating antimicrobial wound dressings, biofilm formation on biomedical polymers, testing novel toothpaste ingredients, and testing biofilm prevention and removal agents. The MBL is also researching the role of biofilms in Lyme disease with funding from a private foundation. The MBL is a prime example of integration at the CBE, bringing together applied biomedical science, industrial interaction, and student educational opportunities.

**Standardized Biofilm Methods Laboratory**

The Standardized Biofilm Methods Laboratory (SBML) was designed to meet research and industry needs for standard analytical methods to evaluate innovative biofilm control technologies. SBML staff and students develop, validate, and publish quantitative methods for growing, treating, sampling, and analyzing biofilm bacteria. The SBML members work with international standard setting organizations (ASTM International, IBRG, and OECD) on the approval of biofilm methods by the standard setting community. Under a contract with the U.S. Environmental Protection Agency (EPA), the SBML provides statistical services relevant to the EPA's Office of Pesticide Programs Microbiology Laboratory Branch to assess the performance of antimicrobial test methods—including those for biofilm bacteria. The SBML received funding from the Burroughs Wellcome Foundation to develop a method for assessing the prevention of biofilm on surface modified urinary catheters. In addition, they conduct applied and fundamental research experiments and develop testing protocols for product specific applications. Methods include: design of reactor systems to simulate industrial/medical systems; growing biofilm and quantifying microbial abundances and activity; testing the efficacy of chemical constituents against biofilms; and microscopy and image analysis of biofilms. SBML staff offer customized biofilm methods training workshops for CBE students, collaborators, and industry clients.

**Microbial Ecology and Biogeochemistry Laboratory**

Research in the Microbial Ecology and Biogeochemistry Laboratory (www.foremanresearchgroup.com) lies at the intersection of microbial and ecosystem ecology and uses a combination of field and laboratory studies, as well as approaches ranging from the single-cell to the community level. Staff in this lab are interested in understanding how the environment controls the composition of microbial communities and how, in turn, those microbes regulate whole ecosystem processes such as nutrient and organic matter cycling. Ongoing research examines carbon flux through microbial communities, with the long-term goal of improving predictions of carbon fate (metabolism to CO2, sequestration into biomass, long-term storage in ice) in the context of a changing environment. Additionally, they are interested in physiological adaptations to life in extreme environments, as extremophiles are natural resources for the discovery of pigments, biosurfactants, novel enzymes and other bioactive compounds of industrial relevance.

**Microfluidics Laboratory**

Dr. Connie Chang runs a soft materials and microfluidics laboratory to study microbes (bacteria, biofilms, and viruses). Dr. Chang is applying drop-based microfluidics—the creation and manipulation of picoliter-sized drops of fluid—for high-throughput screening and assaying in biology. Her lab is developing novel tools for quantifying the behavior of individuals and how they can collectively contribute to large-scale population dynamics. Ongoing projects within her group include the screening of persisters and dormant bacteria cells in biofilms and the study of influenza evolution and population dynamics. Dr. Chang has shared laboratory space in the CBE and an individual laboratory space in the Chemistry and Biochemistry Building (CBB) at MSU. The laboratory spaces include common space for equipment, chemical storage, freezers and reagents. The lab is outfitted with a qPCR machine and also includes a dedicated a room for epifluorescence microscopy and a custom built microscope stand (200 square feet). The lab contains all the equipment and instrumentation necessary for fabrication of new devices, microfluidics handling, PCR, and cell culture.

**Microsensor Laboratory**

The Microsensor Laboratory provides the capability of measuring microscale chemical and physical parameters within biofilms, microbial mats and other compatible environments. The Microsensor Laboratory has the capability to measure spatial concentration profiles using sensors for oxygen, pH, hydrogen sulfide, nitrous oxide and some custom-made electrodes. All electrodes are used in conjunction with computer-controlled micromanipulators for depth profiling. A Leica
A stereoscope is used to visualize the sensors while positioning them on the biofilm surface. The laboratory has experience with diverse microsensor applications including biofilms in wastewater, catheters and hollow fiber membrane systems in addition to algal and fungal biofilms.

**OTHER Montana State University facilities available for collaborative research**

**Montana Nanotechnology (MONT) Facility**
The MONT facility was formed from a $3 million NSF grant awarded to MSU in September of 2015. This collaborative facility includes the Montana Microfabrication Facility (MMF), the Imaging and Chemical Analysis Lab (ICAL), the CBE, the MSU Mass Spectrometry facility, and the Center for Bio-Inspired Nanomaterials. MONT provides researchers from academia, government and companies large and small with access to university facilities with leading-edge fabrication and characterization tools, instrumentation and expertise within all disciplines of nanoscale science, engineering and technology.

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

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

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

- Atomic Force Microscope (AFM)
- Field Emission Scanning Electron Microscope (FE SEM)
- Scanning Electron Microscope (SEM)
- Small-Spot X-ray Photoelectron Spectrometer (XPS)
- Time-of-Flight Secondary Ion Mass Spectrometer (ToF-SIMS)
- X-Ray Powder Diffraction Spectrometer (XRD)
- Scanning Auger Electron Microprobe (AUGER)
- Epifluorescence Optical Microscope
- Microplotting System
- Critical Point Drying
- Video Contact Angle System

For more information on each system, see the ICAL web site at: http://www.physics.montana.edu/ical/
**CBE Computer Facilities**

The CBE maintains several dedicated computational and data storage computer systems including 10 high performance data and image analysis workstations and servers in addition to three large storage servers. The CBE maintains a small to mid-scale computational cluster for modeling and analysis. The center provides personal workstations for staff and graduate students that are connected to the MSU computer network. A student computer laboratory offers nine state-of-the-art PCs along with scanning and printing services. Additionally, CBE staff and students have access to the centrally maintained computational cluster for data manipulation, analysis, and mathematical modeling. This cluster consists of 77 nodes with a total of 1300 hyper-threaded cores and 22 teraflops of computing power.