2022 APPENDIX

Center for Biofilm Engineering

Montana State University
Bozeman

Reporting Period:
June 1, 2021–May 31, 2022

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RESEARCH

EDUCATION

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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 | CO_2 sequestration | biobarriers | 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 |anaerobic systems

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

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RESEARCH:

2021–2022 CBE GRANT-FUNDED RESEARCH ACTIVITY

Current CBE Research Grants for Fiscal Year 2022 (July 1, 2021 to June 30, 2022)			
Research Area	**Title**	**Principal Investigator**	**Funding Agency**
Biofilm Mechanics	Exploring Biofilm Material Properties with Micromechanical Tools	Wilking	NSF
Biofilm Mechanics	Collaborative Research: Modeling Gastric Mucus Layer Physiology with Application to Helicobacter Pylori and Gastric Organoids	Wilking	UTAUNI
Biofilm Mechanics	3D-Printing of Microbial Communities for Optimal Resource Processing	Wilking	ARREOF
Biofilm Mechanics	VIPER: Viral Interdiction through Population Engineering and Restructuring	Chang	NCSU
Biofilm Mechanics	CAREER: Understanding Spatial Heterogeneity in Biofilms Using Colloidal Engineering	Chang	NSF
Biofilms in Nature	SLICE: Spectral Signs of Life in Ice	Foreman	NASA
Biofilms in Nature	Eradication of Microbial Contamination in Metal Working Fluids	Foreman	NSF
Biofilms in Nature	Continued Monitoring of the Bridger Bowl Wetland System	Stein	Bridger Bowl
Energy Solutions	Lipid derived biofuels: Bicarbonate induced triacylglycerol accumulation in microalgae	Peyton	Church & Dwight
Environmental Substance Technologies	Cooperative research program on constructed wetland design and implementation	Stein	USFWS
Environmental Substance Technologies	Building Genome-to-Phenome Infrastructure for Regulating Methane in Deep & Extreme Environments	Gerlach	South Dakota School of Mines
Environmental Substance Technologies	Application of Biofilm Covered Carbon Particles as a Microbial Inoculum Delivery System in Weathered PCB Contaminated Sediment*	Stewart	University of Maryland
Environmental Substance Technologies	Sulfate reducer biofilm transcriptomics and thermodynamics under transient conditions	Fields	EXXMOB002
Environmental Substance Technologies	Developing Biomineralization Technology for Ensuring Wellbore Integrity	Gerlach	Montana Emergent Technologies Inc
Environmental Substance Technologies	Bio-cement Coating of Waste Ores and Tailings	Lauchnor	Pegasus Technical Services
Environmental Substance Technologies	Permeability Control for Enhanced Oil and Gas Recovery in Unconventional Reservoirs Using Advanced Mineral Precipitation Technologies	Phillips	Montana Emergent Technologies Inc
Environmental Substance Technologies	A comprehensive strategy for stable, high productivity cultivation of microalgae with controllable biomass composition	Gerlach	University of Toledo

Medical Biofilms	Resensitization of Bacteria in Biofilms to Antibiotics	Stewart	DOD (USAMRAA)
Medical Biofilms	Synergy between omics, symptoms, and healing trajectories of venous ulcers	Stewart	University of Florida
Medical Biofilms	Designing Immunomodulatory Antibiofilm Biomaterials	Stewart	University of Copenhagen
Methods Development	Methods to assess biofilm prevention on medical devices	Goeres	Burroughs Wellcome Fund
Methods Development	Antimicrobial Test Method - Statistical Support & Consultation	Goeres	EPA
Methods Development	Biofilm and Biomineralization Methods Development in Support of CRC 1313 Projects C04 and C05	Cunningham	Deutsche Forschungsgemeinschaft
Modeling	Predictive Multiscale Modeling of Microbial Consortia Biofilms	Carlson	NIH
Modeling	Development of Robust Microbial Communities through Engineered Biofilms	Carlson	ARREOF
Modeling	A Robust Biofilm-Biomat Reactor for Conversion of Mission-Relevant Feedstocks to Products	Carlson	Sustainable Bioproducts
Physiology & Ecology	Environmental Networks Integrated with Genomes and Molecular Assemblies	Fields	Lawrence Berkley National Laboratory
Physiology & Ecology	Mineral Recovery from Urine - An Alternative Approach for Providing Nutrient for Primary Production in a Controlled Ecological Life Support System for Long-Term Space Missions[1]	Gerlach	NASA
Water Systems	Strengthening Little Big Horn College Research Capacity through Improving Rural Families' Access to Safe Drinking Water, Crow Reservation, Montana	Eggers	Little Bighorn College
[1]NASA EPSCOR			

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FY22 New CBE Research Grants (July 1, 2021 to June 30, 2022)

New CBE Research Grants Awarded in Fiscal Year 2022 (July 1, 2021 to June 30, 2022)				
Sponsor	**Title**	**PI**	**Period**	**Award Amount**
Bridger Bowl	Continued Monitoring of the Bridger Bowl Wetland System*	Otto Stein	1 Yr	$36,000
NSF	FMSG: Biologically assembled and Recycled Construction and Structural materials (BRICS)	Chelsea Heveran	2 Yrs	$474,516
City of Bozeman	Bozeman Pilot Wetland - City	Otto Stein	4 Yr	$50,000
US Economic Development Administration	Sensor system to detect biofilm growth in CNC machines	Stephan Warnat	1 Yr	$13,450
NIH	How Do a Few Attached Staphylococcus aureus Bacteria Evade Innate Immunity to Initiate Biofilm Infection on an Implanted Medical Device?	Philip Stewart	1 Yr	$510,586
NIH	Genomic surveillance of SARS-CoV-2 across the state of Montana	Connie Chang	2 Yr	$650,513
USDOE	High pH/high alkalinity cultivation for Direct Atmospheric Air Capture and Algae Bioproducts	Robin Gerlach	2 Yr	$2,000,000
NSF	MIM: Deciphering and Optimizing Cross-Domain Interactions to Increase Productivity in High pH-High Alkalinity Microalgae Communities	Robin Gerlach	5 Yr	$1,191,654
NASA	NASA FINESST: Madeline Garner Testing Solid-State Nanopore Technology for Detecting DNA and RNA in Laboratory and Field Experiments: Icy World Analogs	Christine Foreman	3 Yr	$45,000
NSF	Life in Ice: Probing microbial englacial activity through time	Heidi Smith	3 Yr	$481,268
Wright Patterson Air Force Base	Biomaterial Structure Reinforcement Assessment	Mohammad Khosravi	1 Yr	$234,933
NASA	Integrated Biofilm Control Strategies for Water Systems During Extended Space Flight	Philip Stewart	3 Yr	$750,000
NSF	Engineering mixed microbial communities & bioreactor configurations to optimize biotransformation processes for metal and metalloid bioremediation and biorecovery	Erika Espinosa Ortiz	2 Yr	$136,638
University of Tennessee	Of ice and brine: Persistence strategies in a chaotropic, Antarctic exobiological analogue	Christine Foreman	3 Yr	$76,291
DARPA	VIPER: Viral Interdiction through Population Engineering and Restructuring*	Connie Chang	1 month	$72,380
MTDEQ	Bozeman Pilot Wetland - MDEQ	Otto Stein	2.5 Yr	$180,000
	Total Grant Awards to CBE in Fiscal Year 2022			**$6,903,229**
	*Additional funding awarded to existing grants in FY22 (budget increased by the amount listed)			

FY 2022 New Award Credit to CBE on next page

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New Research Grants with Credit Given to CBE FY2022						
Sponsor	**Title**	**PI**	**Period**	**Award Amount**	**Credit %**	**Award to CBE**
USDA	The impact of the maple sap microbiome on syrup quality	Seth Walk	3 Yr	$499,010	100%	$499,010
NRT	NRT-URoL: Decoding the Mechanisms Underpinning Biofilm Function and Architecture in Extreme Environments	Brent Peyton	5 Yr	$2,984,140	50%	$1,492,070
NASA EPSCoR	Detection of pathogenic microorganisms in NASA water systems using aptamer functionalized sensors in µ-gravity	Stephan Warnat	1 Yr	$24,984	25%	$6,246
USDA	Persistence mechanisms of Mycoplasma ovipneumoniae in the ovine respiratory tract	Diane Bimczok	3 Yr	$644,000	5%	$32,200
USDA NIFA	Budgeting for Climate Change: Carbon Cost of a Healthy Root Microbiome Under Environmental Stress	Brent Peyton	2 Yr	$120,000	100%	$120,000
MAS-KOEPNICK	Microbially-mediated nitrate-dependent iron oxidation as a novel in situ treatment of selenium and nitrate in groundwater	Brent Peyton	1 yr	$1,500	100%	$1,500
Pennsylvania State University	The Molecular Basis of Survival to Membrane-Targeting Bacterial Control Methods, and Implications for Disease Control	Connie Chang	2 Yr	$147,936	50%	$73,968
USDOE	Thermally Induced Calcite Precipitation (TICP) as a method to control Hydraulic Properties in Enhanced Geothermal Systems	Adrienne Phillips	3 Yr	$437,363	45%	$196,813
NSF	CAREER: Additive Manufacturing of Hierarchically Structured, Sustainable, Multi-Component Materials	Cecily Ryan	5 Yr	$697,158	20%	$139,432
Total Grant Credit Awarded to CBE in Fiscal Year 2022						**$2,561,239**

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RESEARCH:
PUBLICATIONS
June 2021–May 2022

2021 Publications

NOTE:
2021-001 through 2021-022 are listed in 2021 Appendix

2021 Publications

Altae-Tran, Han, Soumya Kannan, F. Esra Demiricioglu, Rachel Oshiro, Suchita P. Nety, **Luke J. McKay**, Mensur Dlakic, William P. Inskeep, Rhiannon K. Macraw, Eugene V. Koonin, Feng Zhang, "The widespread IS200/IS605 transposon family encodes diverse programmable RNA-guided endonucleases," *Science*, 374(6563):57-65. 21-023.

Franklin, Michael J., **Elizabeth Sandvik**, Sila Yanardag, **Kerry S. Williamson** "Functional characterization of the *Pseudomonas aeruginosa* ribosome hibernation-promoting factor," *J Bacteriol*, 2020, 202(19):e00280-20. 21-024.

King, Michelle M., Biraj B. Kayastha, **Michael J. Franklin**, Marianna A. Patrauchan, Calcium Regulation of Bacterial Virulence. In: Islam M. (eds) Calcium Signaling. *Advances Exp Med Biol*, 2020, 1131:827-855. 21-025.

Trudgeon, Benjamin^, **Markus Dieser**, Narayanaganesh Balasubramanian, **Mitch Messmer**, **Christine M. Foreman**, "Low-temperature biosurfactants from polar microbes," *Microorganism*, 2020, 8(8):1183. 21-026.

Chlumsky, Ondrej, **Heidi J. Smith**, **Albert E. Parker**, **Kristen Brileya**, **James N. Wilking**, Sabina Purkrtova, Hana Michova, Pavel Ulbrich, Jitka Viktorova, Katerina Demnerova, "Evaluation of the antimicrobial efficacy of N-Acetyl-L-cysteine, rhamnolipids, and usnic acid—novel approaches to fight food-borne pathogens," *Intl J Molec Sci*, 2021, 22(21):11307. 21-027.

McKay, Luke J., **Heidi J. Smith**, **Elliott P. Barnhart**, Hannah D. Schweitzer, Rex R. Malmstrom, Danielle Goudeau, **Matthew W. Fields**, "Activity-based, genome-resolved metagenomics uncovers key populations and pathways involved in subsurface conversions of coal to methane," *ISME J*, 2021, 1-12. 21-028.

Smith, Heidi J., Hannah D. Schweitzer, **E.P. Barnhart**, W. Orem, **R. Gerlach**, **M.W. Fields**, "Effect of an algal amendment on the microbial conversion of coal to methane at different sulfate concentrations from the Powder River Basin, USA," *Intl J Coal Geol*, 2021, 248:103860. 21-029.

Azevedo, Nuno F., Jontana Allkja, **Darla M. Goeres**, "Biofilms vs. cities and humans vs. aliens – a tale of reproducibility in biofilms," *Trends Microbiol*, 2021, 29(12):1062-1071. 21-030.

Marlow, J., R. Spietz, K.-Y. Kim, M. Ellisman, Peter Girguis, **Roland Hatzenpichler**, "Spatially resolved correlative microscopy and microbial identification reveal dynamic depth- and mineral-dependent anabolic activity in salt marsh sediment," *Environ Microbiol*, 2021, 23:4756-777. 21-031.

Neto, José A.B., Christine Gaylarde, **Iwona Beech**, Alex C. Bastos, Valéria da Silva Quaresma, Diego G. de Carvalho, "Microplastics and attached microorganisms in sediments of the Vitória bay estuarine system in SE Brazil," *Ocean & Coastal Management*, 2019, 169:247-253. 21-032.

Liu, Shiyu, Rongchang Wang, Cuixiang Ma, Dianhai Yang, Duanxin Li, **Zbigniew Lewandowski**, "Improvement of electrochemical performance via enhanced reactive oxygen species adsorption at ZnO–NiO@rGO carbon felt cathodes in photosynthetic algal microbial fuel cells," *Chem Eng J*, 2020, 391:123627. 21-033.

Kirkland, Catherine M., **Arda Akyel**, **Randy Hiebert**, Jay McCloskey, Jim Kirksey, **Alfred B. Cunningham**, **Robin Gerlach**, Lee Spangler, **Adrienne J. Phillips**, "Ureolysis-induced calcium carbonate precipitation (UICP) in the presence of CO2-affected brine: A field demonstration," *Intl J Greenhouse Gas Control*, 2021, 109:103391. 21-034.

Ashley, Kilian, **Katherine J. Davis**, Anna Martini, David S. Vinson, **Robin Gerlach**, **Matthew W. Fields**, Jennifer McIntosh, "Deuterium as a quantitative tracer of enhanced microbial methane production," *Fuel*, 2021, 289:119959. 21-035.

Pettygrove, Brian A., Rachel M. Kratofil, Maria Alhede, Peter Ø. Jensen, Michelle Newton, Klaus Qvortrup, Kyler B. Pallister, Thomas Bjarnsholt, Paul Kubes, Jovanka M. Voyich, **Philip S. Stewart**, "Delayed neutrophil recruitment allows nascent *Staphylococcus aureus* biofilm formation and immune evasion," *Biomaterials*, 2021, 275:120775. 21-036.

Shelton, Jenna L., **Elliott P. Barnhart**, Leslie Ruppert, Aaron M. Jubb, Madalyn S. Blondes, Christina A. DeVera, "Repetitive sampling and control threshold improve 16S rRNA gene sequencing results from produced waters associated with hydraulically fractured shale," *Front Microbiol*, 2020, 11. 21-037.

McKay, Luke J., Olivia D. Nigro, Mensur Dlakić, Karen M. Luttrell, Douglas B. Rusch, **Matthew W. Fields**, William P. Inskeep, "Sulfur cycling and host-virus interactions in aquificales-dominated biofilms from Yellowstone's hottest ecosystems," *ISME J*, 2021, 16:842-855. 21-038.

Johnson, Erick, **Theodore Petersen**^, **Darla M. Goeres**, "Characterizing the Shearing Stresses within the CDC Biofilm Reactor Using Computational Fluid Dynamics," *Microorganisms*, 2021, 9(8):1709. 21-039.

LeFevre, Thomas B., **Dimitri A. Bikos**, **Connie B. Chang**, "Measuring colloid–surface interaction forces in parallel using fluorescence centrifuge force microscopy," *Soft Matter*, 2021, 17:6326–6336. 21-040.

Koenig, Heidi N., **Gregory M. Durling**, **Danica J. Walsh**, Tom Livinghouse, **Philip S. Stewart**, "Novel nitro-heteroaromatic antimicrobial agents for the control and eradication of biofilm-forming bacteria," *Antibiotics*, 2021, 10(7):855. 21-041.

Bjarnsholt, Thomas, Enrico Mastroianni, Klaus Kirketerp-Møller, **Philip S. Stewart**, Aline Meret Mähr, Alonso Domínguez Cabañes, Rune Nørager, "The impact of mental models on the treatment and research of chronic infections due to biofilms," *APMIS*, 2021, 129:598-606. 21-042.

Loss, Manisha, Katherine G. Thompson, Alessandra Agostinho-Hunt, **Garth A. James**, Emmanuel F. Mongodin, Ian Rosenthal, Nancy Cheng, Sherry Leung, Anna L. Chien, Sewon Kang, "Noninflammatory comedones have greater diversity in microbiome and are more prone to biofilm formation than inflammatory lesions of acne vulgaris," *Intl J Dermatol*, 2021, 60(5):589-896. 21-043.

Morrow, Jayne B., Aaron I. Packman, Kenneth F. Martinez, Kevin Van Den Wymelenberg, **Darla Goeres**, Delphine K. Farmer, Jade Mitchell, Lisa Ng, Yair Hazi, Monica Schoch-Spana, Sandra Quinn, William Bahnfleth, Paula Olsiewski, "Critical capability needs for reduction of transmission of SARS-CoV-2 indoors," *Front Bioeng Biosec*, 2021, 9:641599. 21-044.

Espinosa-Ortiz, Erika J., Eldon R. Rene, **Robin Gerlach**, "Potential use of fungal-bacterial co-cultures for the removal of organic pollutants," *Critical Rev Biotechnol*, 2021, 42(3):361-383. 21-045.

Hammerlund, Sarah P., Tomáš Gedeon, **Ross P. Carlson**, William R. Harcombe, "Limitation by a shared mutualist promotes coexistence of multiple competing partners," *Nature Comm*, 2021, 12:619. 21-046.

Cruz, Pablo Martínez, Mikayla A. Wood, **Reha Abbasi**, **Thomas B. LeFevre**, **Stephanie E. McCalla**, "An inexpensive, versatile, compact, programmable temperature controller and thermocycler for simultaneous analysis and visualization within a microscope," *Microfluid Nanofluid*, 2021, 25:40. 21-047.

2022 Publications

Proudfoot, Dylan, Loran Brooks, Christopher H. Gammons, Edwin Barth, Diana Bless, Raja M. Nagisetty, **Ellen G. Lauchnor**, "Investigating the potential for microbially induced carbonate precipitation to treat mine waste," *J Hazard Mats*, 2022, 424(Part C):127490. 22-001.

Messmer, Mitch W., **Markus Dieser**, **Heidi J. Smith**, **Albert E. Parker**, **Christine M. Foreman**, "Investigation of Raman spectroscopic signatures with multivariate statistics: An approach for cataloguing microbial biosignatures," *Astrobiology*, 2022, 22(1):14-24. 22-002.

Schweitzer, Hannah D., **Heidi J. Smith**, **Elliott P. Barnhart**, **Luke J. McKay**, **Robin Gerlach**, **Alfred B. Cunningham**, Rex R. Malmstrom, Danielle Goudeau, **Matthew Fields**, "Subsurface hydrocarbon degradation strategies in low- and high-sulfate coal seam communities identified with activity-based metagenomics," *npj Biofilms Microbiomes*, 2022, 8: 7. 22-003.

Barnhart, Elliott P., Leslie F. Ruppert, **Randy Hiebert**, **Heidi J. Smith**, **Hannah D. Schweitzer**, Arthur C. Clark, Edwin P. Weeks, William H. Orem, Matthew S. Varonka, George Platt, Jenna L. Shelton, Katherine J. Davis, Robert J. Hyatt, Jennifer C. McIntosh, Kilian Ashley, Shuhei Ono, Anna M. Martini, Keith C. Hackley, **Robin Gerlach**, Lee Spangler, **Adrienne J. Phillips**, Mark Barry, **Alfred B. Cunningham**, **Matthew W. Fields**, "In situ enhancement and isotopic labeling of biogenic coalbed methane," *Environ Sci Technol*, 2022, 56(5):3225-3233. 22-004.

Pettygrove, Brian A., **Heidi J. Smith**, Kyler B. Pallister, Jovanka M. Voyich, **Philip S. Stewart**, **Albert E. Parker**, "Experimental designs to study the aggregation and colonization of biofilms by video microscopy with statistical confidence," *Front Microbiol*, 2022, 12: 785182. 22-005.

Amendola, Roberta, **Amit Acharjee**, "Microbiologically influenced corrosion of copper and its alloys in anaerobic aqueous environments: A review," *Front Microbiol*, 2022, 13:806688. 22-006.

Carmody, Caitlin D.^, **Rebecca C. Mueller**, Benjamin Michael Grodner, Ondrej Chlumsky, **James N. Wilking**, Scott G. McCalla, "Chickensplash! Exploring the health concerns of washing raw chicken," *Physics of Fluids*, 34(3). 22-007.

Mahout, Maxime, **Ross P. Carlson**, Sabine Press, "Answer set programming for computing constraints-based elementary flux modes: Application to *Escherichia coli* core metabolism," *Processes*, 8(12):1649. 22-008.

Fredrikson, Jacob. P., Priyanka P. Brahmachary, **Ayten E. Erdoğan**, Zackary K. Archambault, **James N. Wilking**, Ronald K. June, **Connie B. Chang**, "Metabolomic profiling and mechanotransduction of single chondrocytes encapsulated in alginate microgels," *Cells*, 2022, 11(5):900. 22-009.

Meslé, Margaux M., **Rebecca C. Mueller**, Jesse Peach, Brian Eilers, Brian P. Tripet, Brian Bothner, Valérie Copié, **Brent M. Peyton**, "Isolation and characterization of lignocellulose-degrading *Geobacillus thermoleovorans* from Yellowstone National Park," *Appl Environ Microbiol*, 2022, 88(1):e00958-21. 22-010.

Stewart, Philip S., **Kerry S. Williamson**, **Laura Boegli**, Timothy Hamerly, Ben White, Liam Scott, Xiao Hu, Brendan M. Mumey, **Michael J. Franklin**, Brian Bothner, Francisco G. Vital-Lopez, Anders Wallqvist, **Garth A. James**, "Search for a shared genetic or biochemical basis for biofilm tolerance to antibiotics across bacterial species," *Antimicrob Agents Chemother*, 2022, 66(4): e0002122. 22-011.

Bashyal, Ravi K., Matt Mathew, Edward Bowen, **Garth A. James**, David Stulberg, "A novel irrigant to eliminate planktonic bacteria and eradicate biofilm superstructure with persistent effect during total hip arthroplasty," *J Arthroplasty*, 2022, 37(7):S647-S652. 22-012.

Tomasino, Stephen F., Rebecca M. Pines, **Darla M. Goeres**, **Albert E. Parker**, "Interlaboratory evaluations of a standardized quantitative test method for determining the bactericidal and tuberculocidal efficacy of antimicrobial substances on hard non-porous surfaces," *J Microbiol Methods*, 2022, 196:106460. 22-013

Buckingham-Meyer, Kelli, **Lindsey A. Miller**, **Albert E. Parker**, **Diane K. Walker**, **Paul Sturman**, **Ian Novak**^, **Darla M. Goeres**, "Harvesting and disaggregation: An overlooked step in biofilm methods research," *J Visual Exp*, 2022, 182:e62390. 22-014

‡ Industrial or Federal Agency co-author
*Previous Visiting Researcher
Previous staff/faculty
^ Undergraduate Student

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RESEARCH:
PRESENTATIONS
June 2021–May 2022

Diane Walker, CBE Research Engineer: "Biofilm" International Association for Food Protection (IAFP), June 8, 2021, Remote. Invited talk.

Al Parker, CBE Biostatistician: "Improved statistical analysis of microbial data from dilution series" International Society for Bayesian Analysis World Meeting, June 28, 2021, Remote. Invited talk.

Phil Stewart, Faculty, Chemical & Biological Engineering: "A review of the literature on antibiotic resistance transmission within biofilms: Are they really hot spots?" European Congress of Clinical Microbiology and Infectious Diseases" July 9, 2021, Remote. Invited talk.

Darla Goeres, Regulatory Research Professor: "Beer draught line challenge: Biofilm vs. chemistry" Montana Biofilm Meeting, July 13, 2021, Remote. Invited talk.

Elinor Pulcini, Research Faculty, Chemical & Biological Engineering: "Factors that influence microbial ingress into Luer activated valves for intravascular administration sets" Montana Biofilm Meeting, July 13, 2021, Remote. Invited talk.

Erika Espinosa-Ortiz, Research Faculty, Chemical & Biological Engineering: "Fungal biofilms: The good, the bad, and the unknown" Montana Biofilm Meeting, July 13, 2021, Remote. Invited talk.

Garth James Research Faculty, Chemical & Biological Engineering: "The wound microbiome" Montana Biofilm Meeting, July 13, 2021, Remote. Invited talk.

Madelyn Mettler, Graduate Student, Chemical & Biological Engineering: "Impacts of an antibacterial coating on the growth of ISS isolates for single and mixed domain biofilms" Montana Biofilm Meeting, July 13, 2021, Remote. Invited talk.

Matthew Fields, CBE Director: "Secreted, large-scale, extracellular membrane systems in microbial biofilms" Montana Biofilm Meeting, July 13, 2021, Remote. Invited talk.

Matthew McGlennen, Graduate Student, Mechanical & Industrial Engineering: "Sensing slime: Microfabricated sensors to detect biofilm" Montana Biofilm Meeting, July 13, 2021, Remote. Invited talk.

Phil Stewart: "Biofilms as hot spots for gene transfer" Montana Biofilm Meeting, July 13, 2021, Remote. Invited talk.

Reha Abbasi, Graduate Student, Chemical & Biological Engineering: "Matrix in the context of biofilm 3D printing" Montana Biofilm Meeting, July 13, 2021, Remote. Invited talk.

Diane Walker, IAFP annual meeting, Remote, July 18, 2021:

"Microbial Resistance: Is it related to sanitation?" Panel

"Automated hand hygiene monitoring systems reveal insights into behaviors of food handlers in two restaurant types." Poster

Roland Hatzenpichler, Faculty, Chemistry & Biochemistry: "Correlative microscopy approaches link identity, activity, chemistry, and morphology of uncultured cells" Symbiosis Model Systems Virtual Gathering for the Gordon and Betty Moore Foundation, August 4, 2021, Remote. Invited talk.

Adrienne Arnold, Graduate Student, Microbiology & Cell Biology: "Methanotroph acclimation to cultivation stresses and the role of byproduct synthesis,"2021 Metabolic Pathway Analysis Meeting, August 6, 2021, Knoxville, TN. Poster

Roland Hatzenpichler: "Diversity, ecophysiology, activity of uncultured and newly cultured archaea in Yellowstone hot springs" Joint Academic Microbiology Seminar, Singapore, August 23, 2021, Remote. Invited talk.

Roland Hatzenpichler: "Methanogenic archaea and aerobic methane-synthesizing bacteria from diverse Yellowstone habitats" Annual Genomics of Energy & Environment Meeting of the Joint Genome Institute, August 30, 2021, Berkeley, CA. Poster

Darla Goeres: "Biofilm & beer: Chemically aged draught beer line tubing preferentially supports biofilm growth" 20th Interfinish World Congress virtual meeting, September 6, 2021, Remote. Invited talk.

Darla Goeres, International Biodeterioration & Biodegradation Symposium, September 6, 2021, Remote:

"Are academic research and standardization clashing paradigms?" Invited talk.

"Roundtable discussion on industrial and academic perspectives on standard biofilm test methods in the oil and gas sector." Panel

Darla Goeres: "Viewing the microscopic world through a biofilm lens: One woman's journey in STEM" Suzuka College Webinar, September 9, 2021, Remote. Invited talk.

Darla Goeres: "Biofilm & beer draught lines" Webinar at Duke University, September 15, 2021, Remote. Invited talk.

Robin Gerlach, Faculty, Chemical & Biological Engineering: "Algal biofuels and biomineralization: Two tools in the sustainability toolbox" MSU Freshman Symposium, September 25, 2021, Bozeman, MT. Invited talk.

Darla Goeres: "Battling biofilms in beer draught lines" National Brewers Association Collaboration Hour Webinar, October 5, 2021, Remote. Invited talk.

Matthew Fields: "Enabling enhanced biofilm imaging for Department of Defense-Related research at Montana State University and the Northwestern United States" 2021 Defense TechConnect World Innovation Conference, October 20, 2021, National Harbor, MD. Poster

Roland Hatzenpichler: "Methanogenic archaea and methane-synthesizing bacteria in diverse habitats of Yellowstone National Park" Department seminar at the University of Innsbruck, Austria, October 27, 2021, Remote. Invited talk.

Madelyn Mettler: "Single and mixed domain biofilm growth of ISS isolates on materials with an antimicrobial coating," American Society of Gravitational and Space Research Annual Meeting, November 3, 2021, Baltimore, MD. Poster

Arda Akyel, Graduate Student, Chemical & Biological Engineering: "Increasing the temperature and pH range of urease to enable biomineralization sealing of leaky wells," Sustainable Engineering Forum, AIChE Annual Meeting, November 7, 2021, Boston, MA. Invited talk.

Roland Hatzenpichler: "Activity of uncultured microbes in geothermal marine and terrestrial environments" Department seminar at the Helmholtz Centre of Ocean Research, November 29, 2021, Remote. Invited talk.

Darla Goeres: "Biofilms & Aliens: Expanding the biofilm methods paradigm" Anti-Microbial Coating Innovations (AMiCI) online seminar series, December 1, 2021, Remote. Invited talk.

Al Parker: "Are there really no bugs in there?" CBE Regulatory Meeting, February 2, 2022, Washington, D.C. Invited talk.

Madelyn Willis, Graduate Student, Land Resources & Environmental Sciences: "Current Perspectives from 45 Days Inside the HERA Analog" NASA Human Research Program Investigators Workshop, February 7, 2022, Houston, TX, Remote. Invited talk.

Amit Acharjee, Graduate Student, Material Sciences: "Effect of Engineered Grain Boundaries on Microbiologically Influenced Corrosion (MIC) of Copper 101," NSF T2 DDMD Seminar, February 22, 2022, Remote. Invited talk.

Roland Hatzenpichler: "Methanogenic archaea and methane-synthesizing bacteria in diverse habitats of Yellowstone National Park" Leibniz Institute DSMZ - German Collection of Microorganisms & Cell Cultures, March 17, 2022, Braunschweig, Germany. Invited talk.

Roland Hatzenpichler: "Correlative microscopy links identity, activity, chemistry, and morphology of uncultured cells," Faculty of Chemistry, Biofilm Centre, March 29, 2022, University of Duisburg, Germany. Invited talk.

Katrina Lyon, Graduate Student, Microbiology & Cell Biology: "Characterizing the luminal microenvironment of human organoids for studies of gastric pH regulation" APS Experimental Biology Meeting, April 3, 2022, Philadelphia, PA. Invited talk.

Bruce Boles, Graduate Student, Civil Engineering: "Grinnell Glacier Watershed and its Microbial Community," Montana Aquatic Research Symposium, April 7, 2022, Polson, MT. Poster

Garth James: "Biofilm Infections & Human Health" Carroll College Biology Senior Seminar, April 7, 2022, Helena, MT. Invited talk.

Michael Franklin, Faculty, Microbiology & Cell Biology: "Role of ribosome hibernation in the physiological heterogeneity of Pseudomonas aeruginosa biofilms" International Conference - Pseudomonas 2022, April 18, 2022, Atlanta, GA. Invited talk.

Mackenzie Lynes, Graduate Student, Chemistry & Biochemistry: "Phylogenetic and functional diversity of mcrA-encoding archaea in Yellowstone hot springs" Archaea Power Hour, April 19, 2022, Remote. Invited talk.

Darla Goeres: "US EPA Regulatory Guidance: The path to anti-biofilm products in the marketplace" NBIC & CBE Regulations & Standards Workshop, April 20, 2022, Birmingham, UK. Invited talk.

Roland Hatzenpichler: "Novel extremophilic archaea from Yellowstone hot springs and new methods to study their physiology" San Francisco State University, April 21, 2022, San Francisco, CA. Invited talk.

Darla Goeres: "Battling biofilms in beer draught lines" Craft Brewers Conference, May 2, 2022, Minneapolis, MN. Invited talk.

Madelyn Willis: "The living record: Considerations for future biological studies of ice cores" US Ice Core Open Science Meeting, May 24, 2022, La Jolla, CA. Invited talk.

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RESEARCH:

CBE Affiliated Faculty and Their Specialties, 2021–2022

NAME	DEPARTMENT	SPECIALITY
Abbie Richards	Chemical & Biological Engineering	Environmental biotechnology
Adrienne Phillips	Civil Engineering	Environmental biotechnology
Al Cunningham	Civil Engineering	Subsurface biotechnology and bioremediation
Albert Parker	Mathematical Sciences	Mathematics and statistics
Brent Peyton	Chemical & Biological Engineering	Environmental biotechnology and bioremediation
Catherine Kirkland	Chemical & Biological Engineering	Environmental technologies
Cecily Ryan	Mechanical & Industrial Engineering	Polymers & composites
Chelsea Heveran	Mechanical & Industrial Engineering	Biomechanics
Christine Foreman	Chemical & Biological Engineering	Microbial ecology in cold temperature environments
Connie Chang	Chemical & Biological Engineering	Microfluidics
Dana Skorupa	Chemical & Biological Engineering	Microbes in extreme environments
Darla Goeres	Chemical & Biological Engineering	Standardized biofilm methods
Diane Bimczok	Microbiology & Cell Biology	Cell biology
Elinor Pulcini	Chemical & Biological Engineering	Medical biofilms
Ellen Lauchnor	Civil Engineering	Wastewater Systems
Elliott Barnhart	Center for Biofilm Engineering	Environmental biotechnology
Erika Espinosa-Ortiz	Chemical & Biological Engineering	Environmental technologies
Garth James	Chemical & Biological Engineering	Medical biofilms
Heidi Smith	Microbiology & Cell Biology	Biology, imaging
Iwona Beech	Center for Biofilm Engineering	Biocorrosion
James Wilking	Chemical & Biological Engineering	Physical and material biofilm properties
Jeffrey Heys	Chemical & Biological Engineering	Fluid-structure interactions
Jennifer Brown	Chemical & Biological Engineering	Rheology and biofilm mechanics
Joseph Seymour	Chemical & Biological Engineering	Magnetic resonance imaging
Kelly Kirker	Chemical & Biological Engineering	Medical biofilms
Kevin Cook	Mechanical & Industrial Engineering	Tool and machine design
Lewis Cox	Mechanical & Industrial Engineering	Polymer science
Luke McKay	Land Resources & Environmental Sci.	Biofilms in extreme environments, metagenomics
Markus Dieser	Chemical & Biological Engineering	Ecology
Martin Hamilton	Mathematical Sciences	Mathematics and statistics
Matthew Fields	Microbiology & Cell Biology	Environmental biofilms
Michael Franklin	Microbiology & Cell Biology	Molecular genetics, gene expression, alginate biosynthesis; *Pseudomonas*
Otto Stein	Civil Engineering	Engineered waste remediation
Paul Sturman	Civil Engineering	Biofilms in waste remediation, industrial systems
Phil Stewart	Chemical & Biological Engineering	Biofilm control strategies

Rebecca Mueller	Microbiology & Cell Biology	Microbial ecology
Roberta Amendola	Mechanical & Industrial Engineering	Material science and technology
Robin Gerlach	Chemical & Biological Engineering	Environmental biotechnology and bioremediation
Roland Hatzenpichler	Chemistry & Biochemistry	Microbial activity
Ross Carlson	Chemical & Biological Engineering	Metabolic eng., metabolic networks; chronic wounds
Sarah Codd	Mechanical & Industrial Engineering	Magnetic resonance imaging
Scott McCalla	Mathematical Sciences	Applied Dynamic systems
Seth Walk	Microbiology & Cell Biology	Infectious diseases
Stephan Warnat	Mechanical & Industrial Engineering	MEMS, sensors and actuators
Tianyu Zhang	Mathematical Sciences	Mathematical modeling

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RESEARCH:

NEWS HIGHLIGHTS

CBE researchers help NASA tackle spacecraft biofilm problem

CBE PhD student Maddie Mettler (pictured above) and a team of scientists at the CBE have partnered with NASA to explore specialized material coatings and other strategies for preventing microbial buildup in spacecraft water systems. Mettler's research currently focuses on whether various coatings can prevent buildup of two microbes—a bacteria and a yeast—that are commonly found on the space station.

Video Report: CBE researchers use fungi to create a more sustainable cement

Scripps Media Outlet interviewed CBE faculty and students about their work with fungi and plastics to help make cement more eco-friendly without compromising strength. Featured faculty and students: **Chelsea Heveran** (assistant professor, mechanical & industrial engineering), **Erika Espinosa-Ortiz** (assistant research professor, chemical and biological engineering), **Adrienne Phillips** (associate professor, civil engineering), and students **Ethan Viles** (graduate student, mechanical and industrial engineering) and **Michael Espinal** (undergraduate student in mechanical and industrial engineering). The interview has aired on several ABC affiliates around the country.

CBE and TBI receive $3 million NSF grant to support innovative graduate research on extreme microbes

With a $3 million grant from the National Science Foundation, CBE and the Thermal Biology Institute (TBI) will advance cutting-edge research while helping to pioneer a new model of graduate education designed to prepare scientists and engineers for a wide range of impactful careers.

MSU researchers seek to optimize algae biomaterials production

With a series of recently awarded grants totaling $6.4 million, researchers at the Center for Biofilm Engineering and their collaborators are exploring ways to optimize the use of algae for making biofuel and other products while removing carbon dioxide from the air.

Journal Cover Image

Congratulations! to **George Schaible**, MSU-CBE PhD candidate in chemistry and biochemistry, on earning a yearlong cover image for the ISME Journal. In this image correlative fluorescence and electron microscopy reveal the identity and morphology of obligate multicellular magnetotactic bacteria (MMB) living in salt marsh sediment. *ISME J*, 16(1), January 2022.

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CBE Affiliated Faculty & Staff Awards & Appointments

2022 MSU Faculty Honors

Montana State University recognized CBE faculty and staff with the 2022 Spring Awards of Excellence. The awards recognize achievements in research, teaching, outreach, and creative projects. CBE recipients of MSU's faculty and staff awards are:

Connie Chang, Associate Professor of Chemical & Biological Engineering
VPREDGE Award for Meritorious Technology/Science

Kevin Cook, Professor of Mechanical & Engineering Technology
Academic Advising Award

Christine Foreman, Professor of Chemical & Biological Engineering
Women in Science Distinguished Professor Award

Phil Stewart, Regents Professor of Chemical & Biological Engineering
Fox Faculty Award

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New Staff

CBE welcomed new staff to its roster of highly productive researchers

Tim Borgogna, postdoctoral researcher for Dr. Phil Stewart
PhD: Microbiology and Immunology from Montana State University
Current project: Host-pathogen interactions on implanted medical surfaces
Hometown: San Diego, California
Personal interests/hobbies: Hunting, fishing, and running
Fun fact: Tim got into trail running during the pandemic and ran his first ultra this past summer. Go Tim!

Micah Coburn, lab manager, CBE Bioprocessing Laboratory
Degree(s): Biological Engineering from Montana State University and Social Work from University of Montana
Responsibilities: Micah oversees all technical operations for the CBE Bioprocessing Lab, which is home to four CBE faculty and 30 undergrad and graduate students.
Hometown: Arlee, MT
Personal interests/hobbies: Baking and biking
Fun fact: Micah's favorite book is "Ishmael" and describes it as a "must read!"

Ranalda Tsosie, postdoctoral researcher for Dr. Ellen Lauchnor
PhD: Environmental Science/Chemistry from University of Montana
Current project: The optimization of SPC-POU filter and its application of well water treatment within Indigenous lands.
Hometown: Tółłkan, AZ (Navajo Nation)
Personal interests/hobbies: Sewing, beading, weaving, baking
Fun fact: Ranalda is animal lover—she has two dogs, Pudge and Bucket; a Guinea pig, Betty; and a rabbit named Bodie.

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EDUCATION:

Undergraduate Students: Summer 2021, Fall 2021, Spring 2022

*****Graduating ‡Native American

1.	Anderson, Rachel (Carlson)	F	Chemical & Biological Engineering	Jackson, WY
2.	*Bauer, Catherine (Peyton)	F	Chemical & Biological Engineering	Saint Paul, MN
3.	Boden, Farli (Heveran)	F	Architecture	Sandpoint, ID
4.	Bomber, Allyson (Phillips)	F	Civil Engineering	Corvallis, OR
5.	Bruhl, Katerina (Fields)	F	Microbiology & Cell Biology	Maple Valley, WA
6.	Buggy-Agresti, Eli (Wilking)	M	Chemical & Biological Engineering	Sacramento, CA
7.	Buckner, Elizabeth (Goeres)	F	Cell Biology & Neuroscience	Kalispell, MT
8.	Burke, Aspen (Foreman)	F	Chemical & Biological Engineering	Windsor, MA
9.	Carey, Taylor (Peyton)	F	Chemical & Biological Engineering	Wasilla, AK
10.	*Clark, Kaylin (Gerlach)	F	Mechanical & Industrial Engineering	Parker, CO
11.	Cumming, Atticus (Wilking)	M	Directed Interdisciplinary Studies	Bozeman, MT
12.	Denny, Christina (Lauchnor/Stein)	F	Civil Engineering	Bozeman, MT
13.	Devine, Connor (Heveran)	M	Chemical & Biological Engineering	Bozeman, MT
14.	*Donaldson, Tigan (Gerlach/ Lauchnor)	M	Civil Engineering	Fairbanks, AK
15.	*Dreesbach, Hannah (Fields)	F	Chemical & Biological Engineering	Helena, MT
16.	*Du, Martina (Carlson)	F	Chemical & Biological Engineering	Kent, WA
17.	*Espinal, Michael (Heveran)	M	Mechanical & Industrial Engineering	Vacaville, CA
18.	Evans, Emily (Espinosa-Ortiz/Gerlach)	F	Microbiology & Cell Biology	Fort Shaw, MT
19.	Haab, Amanda (Fields)	F	Microbiology & Cell Biology	Helena, MT
20.	*Hemmah, Ashlyn	F	Civil Engineering	Lead, SD
21.	*Holcomb, Charles (Gerlach)	M	Chemical & Biological Engineering	Great Falls, MT
22.	*Jackson, Lauren (Foreman)	F	Mathematical Sciences	Sedalia, CO
23.	Jackson, Ruby	F	Mechanical & Industrial Engineering	Kalama, WA
24.	Jubenville, John (Wilking)	M	Computer Science	Eagan, MN
25.	*Kelderman, Samantha (Phillips)	F	Chemical & Biological Engineering	Issaquah, WA
26.	Knutson, Keigan (Livinghouse/Stewart)	M	Microbiology & Cell Biology	Kalispell, MT
27.	Kohl, Sandra (Gerlach)	F	Civil Engineering	Englewood, CO
28.	*Kozisek, Kayla (Gerlach)	F	Chemical & Biological Engineering	Boise, ID
29.	*Lauf, Jenna (Phillips)	F	Civil Engineering	Helena, MT
30.	Martin, Evan (Chang)	M	Chemical & Biological Engineering	Helena, MT
31.	Miller, Kyle (Gerlach)	M	Ecology	Kalispell, MT
32.	Miller, Madeleine (Warnat)	F	Mechanical & Industrial Engineering	Wasilla, AK
33.	McGurty, Lisa (Gerlach)	F	Chemical & Biological Engineering	Bozeman, MT
34.	Moody, Maya (Heveran)	F	Chemistry & Biochemistry	Concord, NH
35.	*Murray, Abigail (Phillips)	F	Civil Engineering	Murrieta, CA
36.	Nelson, Genevieve (Livinghouse/Stewart)	F	Chemistry & Biochemistry	Corvallis, OR
37.	*Newby, Audrey (James)	F	Microbiology & Cell Biology	Eau Claire, WI
38.	Novak, Ian (Goeres)	M	Chemical & Biological Engineering	Bozeman, MT
39.	Ostrem, Kathleen (Wilking)	F	Ecology	Wilmette, IL
40.	Pak, Benjamin (Khosravi/Phillips)	M	Civil Engineering	Everett, WA
41.	*Pernat, Madeline (Kirkland	F	Civil Engineering	Victoria, MN
42.	Peterson, Natasha (Peyton)	F	Cell Biology & Neuroscience	Helena, MT
43.	Peterson, Sarah (Brown)	F	Chemical & Biological Engineering	Aurora, CO
44.	Rasch, Rory (Warnat)	M	Mechanical & Industrial Engineering	Bozeman, MT
45.	Renner, Konrad (James)	M	Microbiology & Cell Biology	Eagle River, AK
46.	Ritter, Kadin (Warnat)	M	Mechanical & Industrial Engineering	Golden, CO
47.	Rupp, Rachel (Fields)	F	Microbiology & Cell Biology	Laurel, MT
48.	Rux, Kylee (Heveran/Phillips)	F	Civil Engineering	Billings, MT
49.	Schoderbek, Samuel (Gerlach)	M	Civil Engineering	Bend, OR
50.	*Shikany, Jonathan (Peyton)	M	Chemical & Biological Engineering	Bellingham, WA
51.	Shonka, Jack (Gerlach)	M	Civil Engineering	Williamsburg, VA

52.	*Sickafoose, Ian (Wilking)	M	Chemical & Biological Engineering	Albuquerque, MN
53.	*Strautmanis, Uve (Fields)	F	Microbiology & Cell Biology	Cedarburg, WI
54.	*Taylor, Molly (Gerlach)	F	Civil Engineering	Bozeman, MT
55.	Teska, Christy (Foreman)	F	Chemical & Biological Engineering	Stow, MA
56.	Wearmouth, Antonia (Stein/Lauchnor)	F	Civil Engineering	Vancouver, Canada
57.	*Welch, Alyson (Gerlach)	F	Chemical & Biological Engineering	Rochester, MN
58.	Welch, Eric (Franklin)	M	Microbiology & Cell Biology	Rochester, MN
59.	Wolf, Joelle (Kirkland)	F	Civil Engineering	Blaine, MN

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Undergraduates Summary: 2021–2022

Department	Male	Female	Total
Architecture		1F	1
Cell Biology & Neuroscience		2F	2
Chemical & Biological Engineering	7M	12F	19
Chemistry & Biochemistry		2F	2
Civil Engineering	4M	11F	15
Computer Science	1M		1
Directed Interdisciplinary Studies (Honors College)	1M		1
Ecology	1M	1F	2
Mathematical Sciences		1F	1
Mechanical & Industrial Engineering	3M	3F	6
Microbiology & Cell Biology	3M	6F	8
Totals	**20M**	**39F**	**59**

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EDUCATION:

Graduate Students: Summer 2021, Fall 2021, Spring 2022

‡ Native American *Received degree

Masters Candidates

1.	Arnold, Adrienne (Carlson)	F	Microbiology & Cell Biology	Charleston, WV
2.	Bedey, Kayla (Phillips)	F	Civil Engineering	Bozeman, MT
3.	Brush, Kristen (Stein)	F	Civil Engineering	Saco, ME
4.	Collins, Daniel (Warnat/Foreman)	M	Mechanical & Industrial Engineering	Palmer, AK
5.	Delwiche, Jenna (Phillips/Lauchnor)	F	Civil Engineering	Portland, OR
6.	Dorian, Hudson (Phillips/Khosravi)	M	Civil Engineering	Fresno, CA
7.	*Dudiak, Cameron (Wilking/McCalla)	M	Mathematical Sciences	Boulder, CO
8.	*Gunyol, Pinar (Phillips)	F	Civil Engineering	Ankara, Turkey
9.	Keskin, Yagmur (Peyton/Fields)	F	Chemical & Biological Engineering	Tire, Turkey
10.	Ketteler, Haley (Warnat/Foreman)	F	Electrical & Computer Engineering	Edina, MN
11.	*Kilic, Ayse Bengisu (Lauchnor)	F	Chemical & Biological Engineering	Istanbul, Turkey
12.	Lindsay, Travis (Chang)	M	Chemical & Biological Engineering	Eagle, ID
13.	Lyon, Katrina (Wilking/Bimczok)	F	Microbiology & Cell Biology	Highwood, IL
14.	*Massey, KaeLee (Fields)	F	Chemical & Biological Engineering	Billings, MT
15.	Ritu, Tasnim Sultana (Kirkland)	F	Civil Engineering	Joypurhat, BANG
16.	Roehm, Elif (Heveran/Phillips)	F	Mechanical & Industrial Engineering	Sinop, Turkey
17.	Willett, Matthew (Kirkland)	M	Chemical & Biological Engineering	Puyallup, WA

PhD Candidates

1.	Acharjee, Amit (Amendola/Fields)	M	Mechanical & Industrial Engineering	Dhaka, BANG
2.	*Akyel, Arda (Gerlach)	M	Chemical & Biological Engineering	Istanbul, Turkey
3.	Anjum, Sobia (Gerlach)	F	Civil Engineering	Punjab, Pakistan
4.	Ayotte, Stephanie (Lauchnor/Stein)	F	Civil Engineering	Saco, ME
5.	Bodle, Kylie (Kirkland)	F	Civil Engineering	Camano Island, WA
6.	Boles, Bruce (Foreman)	M	Civil Engineering	Knoxville, TN
7.	Brown, Kenna (Heveran)	NB	Mechanical & Industrial Engineering	Grand Junction, CO
8.	Brown, Madelaine (Stewart)	F	Chemical & Biological Engineering	San Jose, CA
9.	Casey, Cailin (Heveran/Jankauski)	F	Mechanical & Industrial Engineering	Melbourne, FL
10.	Christian, William (Hatzenpichler)	M	Chemistry & Biochemistry	Grand Rapids, MI
11.	Cicha, Calvin (Gerlach/Wiedenheft)	M	Microbiology & Cell Biology	Isanti, MN
12.	Durojaye, Olayinka (Kirkland)	F	Civil Engineering	Benin City, Nigeria
13.	Fredrickson, Jacob (Chang)	M	Chemical & Biological Engineering	Puyallup, WA
14.	Gaur, Gauri (Stewart)	F	Microbiology & Cell Biology	Gurgaon, India
15.	Garner, Madeline (Foreman)	F	Molecular Biosciences	Cookeville, TN
16.	Goemann, Hannah (Peyton)	F	Microbiology & Cell Biology	Wells, MN
17.	Hislop, Brady (Heveran)	M	Mechanical & Industrial Engineering	Polson, MT
18.	Hoffman, Carter (Chang)	M	Chemical & Biological Engineering	Carlsbad, CA
19.	Kane, Seth (Ryan/Phillips)	M	Mechanical & Industrial Engineering	Fairbanks, AK
20.	Koenig, Heidi (Stewart/Livinghouse)	F	Chemistry & Biochemistry	Everett, WA
21.	Koepnick, Hannah (Peyton)	F	Chemical & Biological Engineering	Sherman, TX
22.	Kohtz, Anthony (Hatzenpichler)	M	Chemistry & Biochemistry	Omaha, NE
23.	*LeFevre, Thomas (Wilking)	M	Chemical & Biological Engineering	Escanaba, MN
24.	Lynes, Mackenzie (Hatzenpichler)	F	Chemistry & Biochemistry	Cleveland, OH
25.	Marquis, James (Fields)	M	Microbiology & Cell Biology	Mill Valley, CA
26.	McGlennen, Matthew (Warnat/Foreman)	M	Mechanical & Industrial Engineering	Edina, MN
27.	Mettler, Madelyn (Peyton)	F	Chemical & Biological Engineering	Littleton, CO
28.	Meyer, Maranda (Ryan/Wilking)	F	Mechanical & Industrial Engineering	Edmonton, Alberta
29.	Miller, Isaac (Fields)	M	Microbiology & Cell Biology	East Helena, MT
30.	Mozzaffari, Mohammed (Stein/Lauchnor)	M	Civil Engineering	Iran
31.	Neubauer, Michael (Warnat)	M	Mechanical & Industrial Engineering	Rogers, MN
32.	*Pettygrove, Brian (Stewart)	M	Microbiology & Cell Biology	Leesburg, VA

33.	Pratt, Shawna (Chang)	F	Chemical & Biological Engineering	Miles City, MT
34.	*Rathore, Muneeb (Peyton)	M	Chemical & Biological Engineering	Punjab, Pakistan
35.	*Reichart, Nicholas (Hatzenpichler)	M	Chemistry & Biochemistry	Bel Air, MD
36.	Sanchez, Humberto (Chang)	M	Chemical & Biological Engineering	Corona, CA
37.	Schaible, George (Hatzenpichler)	M	Chemistry & Biochemistry	Missoula, MT
38.	Shabazian, Andre (Stewart/Livinghouse)	M	Chemistry & Biochemistry	Palo Alto, CA
39.	Stanley-Thompson, Maribelle (Wilking)	F	Chemical & Biological Engineering	Corvallis, OR
40.	Strupulis, Chloe (Wilking)	F	Chemical & Biological Engineering	Anchorage, AK
41.	Thomas, Mallory (Chang)	F	Microbiology & Cell Biology	Elkhart, IN
42.	Thornton, Isaak (Wilking)	M	Mechanical & Industrial Engineering	Great Falls, MT
43.	Vahidi, Ghazal (Heveran)	F	Mechanical & Industrial Engineering	Tehran, Iran
44.	Viles, Ethan (Heveran/Gerlach)	M	Mechanical & Industrial Engineering	Veradale, WA
45.	Willis, Madelyne (Foreman)	F	Land Resources & Environmental Sciences	Atlanta, GA
46.	Zimlich, Kathryn (Fields)	F	Microbiology & Cell Biology	Dublin, OH

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EDUCATION:
Graduate Students, 2021–2022

19: Chemical & Biological Engineering
MS: 5
2 M Lindsay, Travis: MS, *Chang*
Willett, Matthew: PhD, *Kirkland*
3 F Keskin, Yagmur: MS, *Peyton/Fields*
Kilic, Ayse Bengisu: MS, *Lauchnor*
Massey, KaeLee: MS, *Fields*
PhD: 14
6 M Akyel, Arda: PhD, *Gerlach*
Fredrickson, Jacob: PhD, *Chang*
Hoffman, Carter: PhD, *Chang*
LeFevre, Thomas: PhD, *Wilking*
Rathore, Muneeb: PhD, *Peyton*
Sanchez, Humberto: PhD, *Chang*
8 F Anjum, Sobia: PhD, *Gerlach*
Brown, Madelaine: PhD, *Stewart*
Garner, Madeline: PhD, Foreman
Koepnick, Hannah: PhD, P*eyton*
Mettler, Madelyn: PhD, P*eyton*
Pratt, Shawna: PhD, *Chang*
Stanley-Thompson, Maribelle: PhD, *Wilking*
Strupulis, Chloe: PhD, *Wilking*

7: Chemistry & Biochemistry
PhD: 7
5 M Christian, William: PhD, *Hatzenpichler*
Kohtz, Anthony: PhD, *Hatzenpichler*
Reichart, Nicholas: PhD, *Hatzenpichler*
Schaible, George: PhD, *Hatzenpichler*
Shabazian, Andre: PhD, *Stewart*
2 F Lynes, Mackenzie: PhD, *Hatzenpichler*
Koenig, Heidi, PhD, *Stewart*

11: Civil Engineering
MS: 6
1 M Dorian, Hudson: MS, *Phillips/Khosravi*
5 F Bedey, Kayla: MS, *Phillips*
Brush, Kristen: MS, *Stein*
Delwiche, Jenna: MS, *Phillips/Lauchnor*
Gunyol, Pinar: MS, *Phillips*
Ritu, Tasnim Sultana: MS, *Kirkland*
PhD: 5
2 M Mozzaffari, Mohammed: PhD, *Stein/Lauchnor*
Boles, Bruce PhD, *Foreman*
3 F Ayotte, Stephanie: PhD, *Stein/Lauchnor*
Bodle, Kylie: PhD, *Kirkland*
Durojaye, Olayinka: PhD, *Kirkland*

1: Electrical & Computer Engineering
MS: 1
1 F Ketteler, Haley: MS, *Warnat/Foreman*

1: Land Resources & Environmental Sciences
PhD: 1
1 F Willis, Madelyne: PhD, *Foreman*

1: Mathematical Sciences
MS: 1
1 M Dudiak, Cam: MS, *Wilking/McCalla*

13: Mechanical & Industrial Engineering
MS: 2
1 M Collins, Daniel: MS, *Warnat/Foreman*
1 F Roehm, Elif: MS, *Heveran/Phillips*
PhD: 11
7 M Acharjee, Amit: PhD, *Amendola/Fields*
Hislop, Brady: PhD, *Heveran*
Kane, Seth: PhD, *Ryan/Phillips*
McGlennen, Matthew: PhD, *Warnat*
Neubauer, Michael: MS, *Warnat*
Thornton, Isaak: PhD, *Wilking*
Viles, Ethan: PhD, *Heveran/Gerlach*
3 F Casey, Cailin: PhD, *Heveran*
Meyer, Maranda: PhD, *Wilking/Ryan*
Vahidi, Ghazal: PhD, *Heveran*
1 NB Brown, Kenna: PhD, *Heveran*

10: Microbiology & Cell Biology
MS: 2
2 F Arnold, Adrienne: MS, *Carlson*
Lyon, Katrina: MS, *Wilking*
PhD: 8
4 M Cicha, Calvin: PhD, *Gerlach*
Marquis, James: PhD, *Fields*
Miller, Isaac: PhD, *Fields*
Pettygrove, Brian: PhD, *Stewart*
4 F Gaur, Gauri: PhD, *Stewart*
Goemann, Hannah: PhD, *Peyton*
Thomas, Mallory: PhD, *Chang*
Zimlich, Kathryn: PhD, *Fields*

Total Grads: 63
Total MS: 17 5 M / 12 F
Total PhD: 46 24 M / 21 F / 1 NB

Total Male: 29
Total Female: 33
Total NB: 1

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EDUCATION:

Graduating with advanced degrees: June 2021–May 2022

Bengisu Kilic, MS, Chemical & Biological Engineering, July 2021
Evaluation of methanotrophic activity and growth in a methanotrophic-heterotrophic co-culture

Nicholas Reichart, PhD, Chemistry & Biochemistry, July 2021
Evaluation of methanotrophic activity and growth in a methanotrophic-heterotrophic co-culture

KaeLee Massey, MS, Chemical & Biological Engineering, October 2021
Biofilm distribution in a porous medium reactor emulating shallow subsurface conditions

Thomas LeFevre, PhD, Chemical & Biological Engineering, November 2021
Colloids and diagnostics

Brian Pettygrove, PhD, Microbiology & Cell Biology, March 2022
Characterization of host-pathogen Interactions during early *Staphylococcus aureus* biofilm formation on surfaces

Arda Akyel, PhD, Chemical & Biological Engineering, April 2022
Improving pH and temperature stability of urease for ureolysis-induced calcium carbonate precipitation

Muneeb Rathore, PhD, Chemical & Biological Engineering, May 2022
Algal biofilms and lipids: Bicarbonate amendment and nitrate stress to stimulate lipid accumulation in algal biofilms

Cameron Dudiak, MS, Mathematical Sciences, May 2022
Analysis of dynamic biological systems imagery

Pinar Gunyol, MS, Civil & Environmental Engineering, May 2022
Effects of fine content on calcium carbonate precipitation and thermal properties of bio-cemented sand

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EDUCATION:

Student News and Awards

For MSU senior, graduation marks a continued journey in engineering research

CBE undergraduate researcher **Michael Espinal** earned a bachelor's degree in mechanical engineering last month. A first-generation college student, Michael worked closely with CBE faculty **Chelsea Heveran**, **Adie Phillips**, and **Cecily Ryan** to use microbes to upcycle plastic waste into cement.

Montana State graduate student participates in NASA space simulation

Madelyne Willis landed her name on a NASA mission patch without ever leaving the ground. Willis, a PhD student and CBE-affiliated researcher, spent 45 days in a simulator capsule at Johnson Space Center in Houston as part of the Human Exploration Research Analog experiment – an important step in NASA's preparation to send humans to Mars.

CBE Student Awards

CBE once again dominates '3-Minute Thesis' competition

CBE PhD student **Cailin Casey** won the Judge's Award in this year's 3-Minute Thesis for "What's All the Buzz With Insect Flight?" And CBE collaborator **Ghazal Vahidi** won the People's Choice for, "The Osteocyte: The Key to Curing Bone Fragility in Aging?" Each researcher won an iPad. CBE students have dominated the "3-Minute Thesis," winning seven of eight competitions since its debut at the Norm Asbjornson College of Engineering in 2015.

MSU honors recent CBE graduates with Awards for Excellence

For four decades, Montana State University has recognized its top 40 graduating seniors with an Award for Excellence. Honored students are nominated by faculty and staff based on academic achievements, extracurricular activities, and service to the University and the Bozeman community. Each student recipient is then invited to select a faculty or staff member who has influenced them most during their time at Montana State to also receive an award.

Madeline Pernat, Civil Engineering
Mentor: **Cat Kirkland**, Assistant Professor, Civil Engineering

Aly Welch, Biological Engineering
Mentor: **Dana Skorupa**, Assistant Research Professor, Chemical & Biological Engineering

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2022 MSU Student Research Celebration: CBE Participants

MSU's undergraduate and graduate students shared their research at the annual Student Research Celebration Thursday, April 14, 2022. Among the more than 200 students presenting their research, numerous students were connected with the Center for Biofilm Engineering.

POSTERS

Samantha Kelderman, Chemical & Biological Engineering
Mentor(s): Dana Skorupa; Brent Peyton
Thermophilic bioconversion of degraded plastic wastes to Polyhydroxyalkanoates (PHAs) utilizing *T. thermophilus*

Cailin Casey, Mechanical & Industrial Engineering; Claire Yager
Mentor(s): Chelsea Heveran; Mark Jankauski
The flying insect thoracic cuticle is heterogeneous in structure and in thickness-dependent modulus gradation

Katrina Lyon, Microbiology & Cell Biology;
Mentor(s): Diane Bimczok
Characterizing the luminal microenvironment of human organoids for studies of gastric pH regulation

Madelyn Mettler, Center for Biofilm Engineering;
Mentor(s): Brent Peyton
A simplified laboratory model of a Martian saline seep

Abigail Murray, Civil Engineering
Mentor(s): Adrienne Phillips; Catherine Kirkland
Assessing the use of a multifunctional bio-mineralized composite to treat contaminated stormwater runoff

Tigan Donaldson, Civil Engineering
Mentor(s): Erika Espinosa-Ortiz
Investigating the mechanisms of bacterial transport along fungal hyphae

Martina Du, Chemical & Biological Engineering
Mentor(s): Ross Carlson
Using Synthetic Ecology to Quantify Consortial Interactions in Biofilm and Planktonic Cultures

Nina Denny, Civil Engineering
Mentor(s): Ellen Lauchnor; Chris Allen
Root Biofilms and Oxygen Transport in Treatment Wetland

Kaylin Clark, Mechanical & Industrial Engineering
Mentor(s): Sobia Anjum
Durability of Microbially Produced Calcium Carbonate Adhesives

Kylee Rux, Civil Engineering
Mentor(s): Chelsea Heveran
Plastic-Reinforced Cement Mortar: A Sustainable Solution for Reducing Global Carbon Emissions

Catherine Bauer, Chemical & Biological Engineering;
Mentor(s): Brent Peyton; Ellen Lauchnor

Isolation of Nitrate-dependent Iron Oxidation Bacteria from a Coal Mine Bioreactor for Reduction of the Toxin Selenium

Madeleine Miller, Mechanical & Industrial Engineering
Mentor(s): Stephan Warnat Biofilm
Growth on NASA-relevant Materials based on Substrate Conditions

Lydia Diehl, Ecology
Mentor(s): Hannah Koepnick, Brent Peyton
Microbiome assembly in the *D. lanuginosum* rhizosphere across a temperature gradient in Yellowstone National Park

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EDUCATION:

CBE Seminar Series: Fall 2021

Montana State University, *Virtual Seminar*, 4:10 p.m. MST

Date	Speaker	Affiliation	Presentation Title
08/26	No Seminar- First week of classes		
09/02	Dr. Yaofa Li	Assistant Professor, Dept. of Mechanical & Industrial Engineering, MSU	Quantifying pore-scale interactions of multiphase flow in porous media using microfluidics
9/09	No Seminar		
9/16	Tony Cooke	Leica Microsystems	Setting the "stage" for the next decade of microscopy at the CBE: Provide input in the context of your research needs for the acquisition of new technology
9/23	No Seminar		
9/30	No Seminar		
10/07	No Seminar -CBE Fall Poster Session		
10/14	No Seminar		
10/21 *10am MDT*	Prof. Martin Ackermann	Professor of Microbial Systems Ecology, Dept. of Environmental Systems Science, ETH Zurich	A single-cell perspective on microbial interactions in spatially structured communities
10/28	No Seminar		
11/01 *11am MDT*	Dr. Sandra Milena Rincon Miranda	Senior Researcher, Team Foods, Bogota, Colombia	Development of an algae mixotrophic biofilm reactor for biomass production
11/04	Dr. Wilhelm Paulander	Director, Clinical Operations, Symcel	Real-time measurements and quantification of biofilm metabolic phenotype using isothermal microcalorimetry
11/11	No seminar-Veterans' Day Holiday		
11/18	Dr. Jacinta Conrad	Frank M. Tiller Professor, Dept. of Chemical & Biomolecular Engineering, University of Houston	Dynamics of bacterial adhesion at interfaces
11/25	No seminar-Thanksgiving Holiday		
12/02	Dr. Sophie Darch	Assistant Professor, Dept. of Molecular Medicine, Dept. of Internal Medicine, Morsani College of Medicine, University of South Florida	Studying mechanisms of disease in spatially structured microbial communities

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EDUCATION:

CBE Seminar Series: Spring 2022

Montana State University, *Hybrid*, 4:10pm MST

Date	Speaker	Affiliation	Presentation Title
1/20	No Seminar- First week of classes		
1/27	No Seminar		
2/3* Hybrid Roberts 321	Dr. Kevin Cash	Assistant Professor, Chemical and Biological Engineering, Colorado School of Mines	Nanosensors for spatiotemporal monitoring of microbial physiology
2/10	No Seminar		
2/17	Dr. Zahra Mahdieh	Postdoctoral Researcher, CBE	Granular Matrigel: Restructuring a trusted extracellular matrix for improved permeability
2/24* Virtual 9am MST	Dr. Desiree Dickerson	Consultant, Academic Mental Health & Well-being	Strategies for managing our well-being in research
3/3* Virtual 10am MST	Prof. Kasper Kragh	Assistant Professor, Bacteriology, Costerton Biofilm Center, Copenhagen, Denmark	Microscopy in biofilm research- A closer look
3/10* Hybrid Roberts 321	Dr. Tomasz Zajkowski	PI, NASA Ames Research Center	An evolutionary perspective on prion-based mechanisms of regulation and adaptation
3/17	No Seminar-Montana State University Spring Break		
3/24	Center For Biofilm Engineering Undergraduate Research Day	Ian Novak, Standardized Biofilm Methods Lab Martina Du, Ross Carlson Lab Uve Strautmanis, Matthew Fields Lab	Recent advancements in standard biofilm methods Using synthetic ecology to quantify consortial interactions in biofilm and planktonic cultures Investigation of complete groundwater denitrification utilizing an environmentally relevant bacterial co-culture
3/31	Dr. Tagbo Niepa	Assistant Professor, Chemical & Petroleum Engineering, University of Pittsburgh	Nanocultures: Controlled microbial communities in sessile drops
4/7	George Schaible	PhD Candidate, Chemistry & Biochemistry, Montana State University, CBE	Investigating cellular differentiation within multicellular magnetotactic bacteria using genomics and correlative microscopy
4/14	Dr. Anita Shukla	Associate Professor, Engineering, Brown University	Smart antimicrobial biomaterials
4/21	Dr. Qian Wang	Assistant Research Professor, Microbiology & Cell Biology, MSU	Aerobic methane synthesis microbes
4/28	Dr. Tim Borgogna	Postdoctoral Researcher, CBE	Host interactions with biofilms on implants: Translating from in vitro to in vivo
5/5	Kirsten Kapp	Professor, Biological Sciences, Central Wyoming College	Exploring the multidimensional world of microplastic pollution

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TECHNOLOGY TRANSFER:

Industrial Associates, 2021–22

Bold, new *Small business member

3M
Abradem Corp*
American Chemet*
Arxada (formerly Lonza)
Baxter Healthcare
CardioQuip*
Church & Dwight Company
Clorox
Decon7 Systems*
DeLaval
Earth Science Laboratories*
Ecolab
ICU Medical, Inc.
Kersia
Kohler
Liberty Biosecurity*
Masco Corporation
Molnlycke
NASA
Next Science*
Novozymes
Olympus
Perfectus Biomed*
PPG
Procter & Gamble Company
Quest Medical
SANUWAVE Health*
Sharklet Technologies*
Smith & Nephew
Spinnaker International*
Sterilex*
STERIS
TerraStryke*
The Sherwin-Williams Company
Zimmer Biomet

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TECHNOLOGY TRANSFER:

Montana Biofilm Meeting July 13–15, 2021

Tuesday, July 13

9:15–9:25
Opening Remarks
Matthew Fields
CBE Director
Professor, Microbiology & Cell Biology, MSU
Paul Sturman, CBE Industrial Coordinator

SESSION 1: Biofilm Matrix
9:25–9:30
Session Introduction
Matthew Fields

9:30–10:10
The biofilm matrix as a cooperative and competitive trait
Hans Steenackers, Assistant Professor, Microbial & Molecular Systems, KU Leuven, Belgium

10:10–10:50
Biofilm mechanics as a surface survival mechanism for them but a drag for us
Paul Stoodley, Professor, Microbial Infection & Immunity; Director, Campus Microscopy & Imaging Facility, The Ohio State University

10:50–11:20 Break

11:20–12:00
Secreted, large-scale, extracellular membrane systems in microbial biofilms
Matthew Fields

12:00–12:40
Matrix in the context of biofilm 3D printing
Reha Abbasi, Postdoctoral Researcher, CBE

12:40–1:00 Break

PANEL DISCUSSION
1:00–2:00
Uncovering the hidden potential and known challenges of the biofilm matrix
Matthew Fields
Sarah Finn, Senior Microbiology Manager, Kersia
Jan Hodges, Director, QA & Regulatory Affairs, Quest Medical
Hans Steenackers
Paul Stoodley
Moderator:
Darla Goeres, Research Professor of Regulatory Science, CBE
Co-Moderator:
Jim Wilking, Associate Professor, Chemical & Biological Engineering, MSU, CBE

Wednesday, July 14

9:15–9:25
Opening Remarks
Matthew Fields
Paul Sturman

SESSION 2: Medical Biofilms
9:25–9:30
Session Introduction
Garth James, PI, Medical Biofilms Laboratory, CBE; search Professor,**9:30–10:10**
The infectious microenvironment and biofilms
Thomas Bjarnsholt, Professor, International Health, Immunology & Microbiology, University of Copenhagen, Denmark

10:10–10:50
The wound microbiome
Garth James

10:50–11:20 Break

11:20–12:00
Factors that influence microbial ingress into luer activated valves for intravascular administration sets
Elinor Pulcini, Assistant Research Professor, Chemical & Biological Engineering, MSU, CBE

SPECIAL PRESENTATION
12:00–12:40
Biofilms as hot spots for gene transfer
Phil Stewart, Regents Professor, Chemical & Biological Eng., MSU, CBE

12:40–1:00 Break

1:00–3:00 Virtual Open House with Posters, Demos, 1:1 Discussions

Thursday
July 15

9:15–9:25
Opening Remarks
Matthew Fields
Paul Sturman

SESSION 3: Industrial Biofilms

9:25–9:30
Session Introduction
Darla Goeres

9:30–10:10
Beer draught line challenge: Biofilm vs. chemistry
Darla Goeres

10:10–10:50
Impacts of an antibacterial coating on the growth of ISS isolates for single and mixed domain biofilms
Madelyn Mettler, PhD Student, Chemical & Biological Eng., MSU, CBE

10:50–11:20 Break

11:20–12:00
Fungal biofilms: The good, the bad, and the unknown
Erika Espinosa-Ortiz, Asst. Research Professor Chemical & Biological Eng., MSU, CBE

12:00–12:40
Sensing slime: Microfabricated sensors to detect biofilm
Matt McGlennen, PhD Student Mechanical & Industrial Eng., MSU, CBE

12:40–1:00 Break

1:00–2:30 IA Strategic Planning Meeting

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TECHNOLOGY TRANSFER:

Anti-Biofilm Technologies: Pathways to Product Development Meeting
February 1-2, 2022

Tuesday, February 1

CBE Industrial Associate Workshop:
Exploring the gaps and opportunities in anti-biofilm product development and the regulatory process

8:15–8:20
Opening Remarks
Matthew Fields
Director, CBE; Professor, Microbiology & Cell Biology, MSU
Paul Sturman, Industrial Coordinator, CBE

SESSION 1: Surface Disinfection
8:20–8:30
Session Introduction
Darla Goeres, PI, Standardized Biofilm Methods Laboratory, Research Professor of Regulatory Science, CBE

8:30–9:00
Where to fit in? How to approach the EPA with a non-traditional technology
Chris Jones, Director, R&D, Sharklet Technologies

9:00–9:30
Regulatory and registration pathways for products making biofilm claims
Luisa Samalot-Freire, Microbiologist, Office of Pesticides Programs, Antimicrobials Division, US EPA

9:30–10:00
Data generation and development of non-public health or public health disinfectant biofilm claims
Denise Fernandez, Senior Consultant, Scientific & Regulatory Consultants

10:00–10:30 Break

PANEL DISCUSSION
10:30–12:00
Biofilm disinfection claims: Leveraging validated methods for new pathways
Denise Fernandez
Stacey Gish, STERIS
Chris Jones
Josh Luedtke, Ecolab
Luisa Samalot-Freire
Moderator: Darla Goeres

12–12:50 Lunch Potomac F

SESSION 2: Medical Technologies
12:50–1:00
Session Introduction
Garth James, PI, Medical Biofilms Laboratory, CBE; Associate Research Professor, Chemical & Biological Engineering, MSU

1:00–1:30
Research relevance and evidence quality in assisting regulatory decision-making for antimicrobial claims
David Grainger, Distinguished Prof. & Chair, Biomedical Eng., Pharm. and Pharm. Chemistry, University of Utah

1:30–2:00
Innovative isn't enough: Advancing clinical technology
Topher Hunter, Medical Science Liaison Manager, Next Science

2:00–2:30
Preclinical performance testing of medical devices with antimicrobial effects: Shifting the focus from bench to bedside
K. Scott Phillips, Regulatory Research Scientist, Center for Device & Radiological Health, US FDA

2:30–3:00 Break

PANEL DISCUSSION
3:00–4:30
Medical biofilm claims: Supporting data and drawing consensus
David Grainger
Jeanne Lee, Next Science
K. Scott Phillips
Laura Wahlen, Baxter Healthcare
Moderator: Garth James

4:30–4:45 Wrap-up
5:00 Reception Chesapeake C

Wednesday, February 2

Program: Biofilm Science and Technology for Regulatory Decision Making

8:20–8:30
Session Introduction
Paul Sturman, Industrial Coordinator, CBE

8:30–9:00
The CBE: Biofilms and Beyond
Matthew Fields, Director, CBE; Professor, Microbiology & Cell Biology, MSU

9:00–9:30
The biofilm matrix as a therapeutic target
Kendra Rumbaugh, Professor, Dept. of Surgery, Texas Tech University Health Sciences Center

9:30–10:00
Designing and quantifying the accuracy of model systems
Marvin Whiteley, Professor, Biological Sciences, Georgia Institute of Technology

10:00–10:30 Break

10:30–11:00
Limits of detection in microbiology
Al Parker, Biostatistician, CBE; Associate Research Prof., Mathematical Sciences, MSU

11:00–11:30
Fluid modeling as a supporting tool for testing and regulation: A case study
Erick Johnson, Associate Professor, Mechanical & Industrial Engineering, MSU, CBE

1:30–12:30
The need for a variety of biocide chemistries to prevent biofilms in paint and coatings
Riaz Zaman, American Coatings Association
Tony Rook, The Sherwin-Williams Co.
Rodney Rees, Thor Specialties, Inc.
Adrian Krygsman, Troy Corporation
Greg Sarnecki, Behr Corporation

12:30–1:30 Lunch Potomac F

1:30–2:00
Recap of regulatory workshop and paths forward
Darla Goeres
Garth James

2:00–2:30
UK perspective on biofilm regulation
Mark Richardson, CEO, National Biofilm Innovation Centre, UK

2:30–3:00
Biofilm test methods, claims and regulation—The EU perspective
Florian Brill, Managing Director, Dr. Brill + Partner GmbH Institute for Hygiene and Microbiology

3:00–3:15 Meeting Wrap-up

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TECHNOLOGY TRANSFER:

NEWS HIGHLIGHTS

CBE welcomed new members to its Industrial Associates Program:

Based in College Station, Texas, **CardioQuip** is a small-business member whose primary product is heater/cooler units for use in surgery. Heater/cooler units control the temperature of patients' blood during some surgeries. According to CardioQuip's website, "… temperature control continues to play a vital role in patient outcomes." CardioQuip's designated representative is Will Stewart.

Ecolab is one of the largest water-treatment/specialty chemical companies in the US, focusing on food safety, pulp and paper, healthcare facilities, and manufacturing. Ecolab's global headquarters is in St. Paul, Minnesota, and has more than 160 offices around the world. Josh Luedtke is the CBE's representative at Ecolab.

Established in 2014, **Liberty BioSecurity** is a founder-funded biotech company based in Arlington, Virginia. It specializes in the development of breakthrough clinical-stage pharmaceuticals and biological-based capabilities for healthcare, industry, and government. "Liberty BioSecurity is committed to improving the human condition through innovation in the life sciences," according to its LinkedIn profile. Sean Riley is the CBE representative.

Molnlycke Health Care, headquartered in Gothenburg, Sweden, makes wound care and single-use surgical products and is a service provider to the healthcare sector. The wound care division includes medical device wound healing solutions such as dressings, compression products, and skin care products. Susanna Roe, technical product manager in the specialty wound care branch, is the CBE contact at Molnlycke.

Spinnaker International LLC, based in Osterville, Massachusetts, is a company that specializes in growing clinically differentiated technologies globally. Spinnaker uses EDTA in numerous medical applications and they are interested in exploring potential controls for biofilm formation in urinary catheters, a leading cause of hospital-acquired infections. Kevin Seifert is the CBE designated representative at Spinnaker International.

TerraStryke, formerly BioStryke, is a soil and groundwater remediation company based in Andover, New Hampshire. TerraStryke has two flagship products, each a biostimulant demonstrated to be effective in the lab and field. They have been used to remediate brownfield redevelopment sites, gas stations, dry cleaners, manufacturing facilities, and residential properties throughout North America and abroad. Kent Armstrong is TerraStryke's designated representative for the CBE.

Kohler, a plumbing-fixture giant, increases CBE program enrollment to 30 company members. Stuart Skinner, based in Kohler's Cheltenham, England, office, is the company's designated representative. Established in 1873, Kohler is a privately held, family-led company that employs more than 36,000 people worldwide.

The CBE Industrial Associates program includes companies from a variety of sectors, including manufacturers of specialty chemicals, medical devices, paints and coatings, food production, and consumer products, and vary in size from local innovators to international corporations.

Now available: 17th Knowledge Sharing Article (KSA) on Standardized Methods

CBE's Standard Biofilm Methods Lab (SBML) announces its 17th Knowledge Sharing Article (KSA) on standardized methods "Antimicrobial Test Methods: Assessing neutralization using ASTM E1054." In 2021, ASTM E1054 was revised to use a different statistical approach for assessing antimicrobial neutralization effectiveness and toxicity. KSA-SM-17 describes why the change was made, walks through examples, and provides software to implement the calculations.

Urinary Catheter Test Method Approved

Darla Goeres, CBE research professor of regulatory science, and collaborators at Burroughs Wellcome are pleased to announce the approval of ASTM Method E3321, which describes how to evaluate antimicrobial urinary catheters for prevention of Escherichia coli biofilm growth.

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TECHNOLOGY TRANSFER:

Industry and Agency Interactions

As the COVID-19 vaccine emerged and travel restrictions lessened, the CBE started again hosting company visits. In fiscal year 2022, the following companies visited the center to meet with CBE researchers and discuss existing and potential projects.

Company	CBE Host	Interaction	Date
Ecolab	Parker, Al	Consulting	November 22, 2021
ICU Medical, Inc	Parker, Al	Consulting	April 4, 2022
Masco Corporation	Sturman, Paul	CBE Visit	February 14, 2022
Procter & Gamble	Parker, Al	Publication	November 8, 2021
Procter & Gamble	Parker, Al	Presentation	November 29, 2021
Sharklet Technologies	Goeres, Darla	CBE Visit	August 30, 2021
Sterilex	Parker, Al	Consulting	September 24, 2021
W.L. Gore & Associates	Sturman, Paul	CBE Visit	April 7, 2022

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OUTREACH:

News Highlights

CBE director to serve on federal energy advisory committee

Matthew Fields, director of MSU's Center for Biofilm Engineering and professor in MSU's Department of Microbiology & Cell Biology, has been selected to serve on a US Department of Energy advisory board.

AMiCI Online Seminar Series

Darla Goeres, CBE research professor of regulatory science, co-presented "Biofilms & Aliens: Expanding the biofilm methods paradigm," with Dr. Nuno Filipe Azevedo, assistant professor in the Faculty of Engineering at University of Porto, as part of the AMiCI online seminar series on Wed., Dec. 1, at 2:00 p.m. GMT/3:00 p.m. CET. AMiCI addresses the challenge of anti-microbial coating innovations to prevent infectious disease in healthcare.

CBE researcher wins international standards award

Darla Goeres received the Professor of the Year Award from ASTM International, the primary organization that develops technical standards for a wide range of materials and other goods. Darla was recognized for her significant role in developing the first standards referenced in regulatory guidelines for biofilm-related consumer products.

Goeres, Sturman take part in Int'l Biodeterioration and Biodegradation Symposium Panel

CBE faculty Darla Goeres and Paul Sturman took part in an international panel discussion on industrial standard biofilm test methods in relation to medical, oil and gas, and corrosion applications. The panel was part of the 18th International Biodeterioration & Biodegradation Symposium held virtually in September 2021.

CBE debuts 'Biofilm First' podcast series

The CBE launched "Biofilm First," a podcast series launched earlier this year. "Biofilm First" explores the research being conducted at the CBE and the talented researchers who are expanding the field. Season 1 of "Biofilm First" launched with interviews with Erika Espinosa-Ortiz and Darla Goeres. Forthcoming interviews include Matthew Fields, Paul Sturman, Heidi Smith, and Dana Skorupa. Interviews with several other researchers are currently being developed and soon be published. Please subscribe to the Biofilm First podcast via your favorite podcast source, including Apple Podcasts, Google Podcasts, Spotify, Amazon Music, and others.

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OUTREACH:

Visiting Researchers

Evan Eshelman
PhD: Physics from York University
Company: Impossible Sensing
Project at the CBE: Impossible Sensing is collaborating with the lab of Dr. Christine Foreman to develop a Spatial Excitation Emission Matrix Spectroscopy instrument (SEEMs) under a DOE Small Business Technology Transfer (STTR) program. SEEMs was designed to perform real-time, in situ assessments of soil organic matter in the field. Monitoring and improving the health and quality of soil is a concern in the agriculture and biofuel industries.
Visiting November 2021-November 2022.

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OUTREACH:

Web image library use 2021-2022

Total image downloads: **113**

Requests for CBE graphics were submitted from **12** of the U.S. states:

Arizona
District of Columbia
Maryland
Massachusetts
Michigan
Montana
New Jersey
Oregon
Pennsylvania
Texas
Virginia
Washington

There were requests from an additional **18** countries:

Argentina
Australia
Brazil
Cameroon
France
Germany
India
Indonesia
Ireland
Japan
Mexico
Netherlands
New Zealand
Phillipines
Sweden
Switzerland
United Kingdom
Vietnam

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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 mm^2 at 12 µm resolution, and a FOV of 10x10 mm^2 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 recombined 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 CO_2 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 innovativeleaders 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 persister 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 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. Back to Table of Contents

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/

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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.

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