2023 APPENDIX

Center for Biofilm Engineering

Montana State University
Bozeman

Reporting Period:
June 1, 2022–May 31, 2023

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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 | built environment

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 | biosensors | Raman spectroscopy

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:

2022–2023 CBE GRANT-FUNDED RESEARCH ACTIVITY

Research Area	Title	PI	Funding Agency
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	CAREER: Understanding Spatial Heterogeneity in Biofilms Using Colloidal Engineering	Chang	NSF
Biofilm Mechanics	High-Throughput, Massively Parallel Antimicrobial Resistance Surveillance Using Drop-Based Microfluidics	Chang	NIH
Biofilm Mechanics	High-throughput droplet qRT-PCR microfluidic platform for quantification of virus from single cells	Loveday	Mayo Clinic
Biofilms in Nature	Eradication of Microbial Contamination in Metal Working Fluids	Foreman	NSF
Biofilms in Nature	NASA FINESST: Madeline Garner Testing Solid-State Nanopore Technology for Detecting DNA and RNA in Laboratory and Field Experiments: Icy World Analogs	Foreman	NASA
Biofilms in Nature	Of ice and brine: Persistence strategies in a chaotropic, Antarctic exobiological analogue	Foreman	University of Tennessee
Biofilms in Nature	DOE STTR: (SEEMS) Spatial Excitation Emission Matrix Spectroscopy Instrument Phase II	Foreman	USDOE
Biofilms in Nature	Life in Ice: Probing microbial englacial activity through time	Smith	NSF
Biofilms in Nature	Mechanisms Enhancing Microbial Survival at Cold Temperature Phase Boundaries	Smith	US Army Research Office
Biofilms in Nature	Continued Monitoring of the Bridger Bowl Wetland System	Stein	Bridger Bowl
Biofilms in Nature	Bozeman Pilot Wetland - City	Stein	City of Bozeman
Biofilms in Nature	Bozeman Pilot Wetland - MDEQ	Stein	MT DEQ
Biomechanics	FMSG: Biologically assembled and Recycled Construction and Structural materials (BRICS)	Heveran	NSF
Energy Solutions	Nitrate Dependent Iron Oxidation	Peyton	SRK Consulting
Energy Solutions	NLC SRF Expert Advisory Meeting	Peyton	SRK Consulting
Environmental Substance Technologies	Building Genome-to-Phenome Infrastructure for Regulating Methane in Deep & Extreme Environments	Gerlach	South Dakota School of Mines
Environmental Substance Technologies	A comprehensive strategy for stable, high productivity cultivation of microalgae with controllable biomass composition	Gerlach	University of Toledo
Environmental Substance Technologies	High pH/high alkalinity cultivation for Direct Atmospheric Air Capture and Algae Bioproducts	Gerlach	USDOE
Environmental Substance Technologies	MIM: Deciphering and Optimizing Cross-Domain Interactions to Increase Productivity in High pH-High Alkalinity Microalgae Communities	Gerlach	NSF

Environmental Substance Technologies	EFRI ELiS: Biofilm-functionalized and -maintained, living infrastructure systems	Gerlach	NSF
Environmental Substance Technologies	Minimizing organic carbon losses to improve net productivity in direct air capture cultivation	Gerlach	University of Toledo
Environmental Substance Technologies	Engineering mixed microbial communities & bioreactor configurations to optimize biotransformation processes for metal and metalloid bioremediation and biorecovery	Espinosa Ortiz	NSF
Environmental Substance Technologies	Biomaterial Structure Reinforcement Assessment	Khosravi	Wright Patterson Airforce Base
Environmental Substance Technologies	Engineered Biological Cement for Surface Hardening in Semi-Aquatic Environments	Khosravi	BioSqueeze (DARPA)
Instrumentation	Real-time Imaging of Transient Protein-protein Interactions in Bacterial Biofilms Using Förster (Fluorescence) Resonance Energy Transfer and Fluorescence Lifetime Imaging Microscopy	Smith	NIH
Instrumentation	Supplement to W911NF1910288 (4W7813): Unlocking Microbial Phenotypes with Stimulated Raman Spectroscopy	Smith	US Army Research Office
Instrumentation	Sensor system to detect biofilm growth in CNC machines	Warnat	US Economic Development Association
Medical Biofilms	Synergy between omics, symptoms, and healing trajectories of venous ulcers	Stewart	University of Florida
Medical Biofilms	How Do a Few Attached Staphylococcus aureus Bacteria Evade Innate Immunity to Initiate Biofilm Infection on an Implanted Medical Device?	Stewart	NIH
Medical Biofilms	Integrated Biofilm Control Strategies for Water Systems During Extended Space Flight	Stewart	NASA
Medical Biofilms	Intravascular Port and Disinfection System (PortProtek)	James	Hyprotek
Methods Development	Antimicrobial Test Method - Statistical Support & Consultation	Parker	EPA
Methods Development	Biofilm and Biomineralization Methods Development in Support of CRC 1313 Projects C04 and C05	Cunningham	Deutsche Forschungsgemeinschaft
Physiology & Ecology	Environmental Networks Integrated with Genomes and Molecular Assemblies	Fields	Lawrence Berkley National Laboratory
Physiology & Ecology	RII Track-2 FEC: Data Driven Material Discovery Center for Bioengineering Innovation	Fields	South Dakota School of Mines
Physiology & Ecology	Enabling Enhanced Biofilm Imaging for Department of Defense-Related Research at Montana State University and the Northwestern United States	Fields	US Department of Defense
Physiology & Ecology	Environmental Networks Integrated with Genomes and Molecular Assemblies	Fields	Lawrence Berkley National Laboratory
Physiology & Ecology	Montana State University Built Environment Surveillance Testbed	Fields	Idaho National Laboratory

Water Systems	Evaluation of bio-mineralization to mitigate acid mine drainage in the Great Falls-Lewistown coal field	Lauchnor	Montana Department of Natural Resources & Conservation

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FY23 New CBE Research Grants

New CBE Research Grants Awarded in Fiscal Year 2023 (July 1, 2022 to June 30, 2023)				
Sponsor	**Title**	**PI**	**Period**	**Award Amount**
University of Utah	*Collaborative Research: Modeling Gastric Mucus Layer Physiology with Application to Helicobacter Pylori and Gastric Organoids	James Wilking	1 Yr	$47,478
City of Bozeman	*Bozeman Pilot Wetland - City	Otto Stein	2 Yr	$70,000
NIH	Real-time Imaging of Transient Protein-protein Interactions in Bacterial Biofilms Using Förster (Fluorescence) Resonance Energy Transfer and Fluorescence Lifetime Imaging Microscopy	Heidi Smith	1 Yr	$66,246
USDOE	DOE STTR: (SEEMS) Spatial Excitation Emission Matrix Spectroscopy Instrument Phase II	Christine Foreman	2 Yr	$149,403
US Army Research Office	Mechanisms Enhancing Microbial Survival at Cold Temperature Phase Boundaries	Heidi Smith	2 Yr	$246,150
US Army Research Office	Supplement to W911NF1910288 (4W7813): Unlocking Microbial Phenotypes with Stimulated Raman Spectroscopy	Roland Hatzenpichler/ Heidi Smith	1 Yr	$1,000,000
BioSqueeze (DARPA)	Engineered Biological Cement for Surface Hardening in Semi-Aquatic Environments	Mohammad Khosravi	1 Yr	$168,718
NSF	EFRI ELiS: Biofilm-functionalized and -maintained, living infrastructure systems	Robin Gerlach	4 Yr	$1,997,499
Mayo Clinic	High-throughput droplet qRT-PCR microfluidic platform for quantification of virus from single cells	Emma Loveday	1 Yr	$168,967
SRK Consulting	NLC SRF Expert Advisory Meeting	Brent Peyton	1 Yr	$51,166
Lawrence Berkley National Lab	Environmental Networks Integrated with Genomes and Molecular Assemblies	Matthew Fields	1 Yr	$792,499
Montana Department of Natural Resources & Conservation	Evaluation of bio-mineralization to mitigate acid mine drainage in the Great Falls-Lewistown coal field	Ellen Lauchnor	9 mo.	$40,585
University of Toledo	Minimizing organic carbon losses to improve net productivity in direct air capture cultivation	Robin Gerlach	5 Yr	$999,993
Idaho National Laboratory	Montana State University Built Environment Surveillance Testbed	Matthew Fields	9 mo.	$30,000
	Total New Grant Awards to CBE in Fiscal Year 2023			**$5,828,704**

FY 2023 New Award Credit to CBE on next page

New Research Grants with Credit Given to CBE FY2023						
Sponsor	**Title**	**PI**	**Period**	**Award Amount**	**Credit %**	**Award Amount to CBE**
NSF	Using Combined Velocimetry, Thermometry and Interferometry to Investigate Contact Line Dynamics During Thin-Film Evaporation on Micro/Nano-Engineered Surfaces	Yaofa Li	5 Yr	$508,085	20%	$101,617
NIH	Aerobic granular sludge: assessing PPCP removal from wastewater	Catherine Kirkland	1 Yr	$123,056	50%	$61,528
NIH	Developing Next-Generation Physiology approaches for human gut microbiome research	Roland Hatzenpichler	5 Yr	$322,729	100%	$322,729
USDA	Smart farming to improve maple syrup quality control and cleaning procedures	Stephan Warnat	3 Yr	$499,283	100%	$499,283
NIH	The need for speed: Stimulated Raman Spectroscopy for human gut microbiome research	Roland Hatzenpichler	1 Yr	$150,000	100%	$150,000
Cornell University (from NSF)	EFRI ELiS: Mechanically Adaptive Living Structural Materials	Chelsea Heveran	4 Yr	$164,989	50%	$82,495
Total Grant Credit Awarded to CBE in Fiscal Year 2023						**$1,217,652**

RESEARCH:
PUBLICATIONS
June 2022–May 2023

NOTE:
2022-001 through 2022-014 are listed in 2022 Appendix

2022 Publications

Triano, Ben, Kevin M. Kappenman, Thomas E. McMahon, Matt Blank, Kurt C. Heim, **Albert E. Parker**, Alexander V. Zale, Nolan Platt, Katey Plymesser, "Attraction, entrance, and passage efficiency of Arctic grayling, trout, and suckers at Denil fishways in the Big Hole River Basin, Montana," *Transactions of the American Fisheries Society*, July 2022, 151(4):453-473. 22-015.

Schaible, George A., Anthony Kohtz, John Cliff, **Roland Hatzenpichler**, "Correlative SIP-FISH-Raman-SEM-NanoSIMS links identity, morphology, biochemistry, and physiology of environmental microbes," *ISME Comm*, June 2022, 2:52. 22-016.

Mahdieh, Zahra, Michelle D. Cherne, **Jacob P. Fredrikson**, **Barkan Sidar**, **Humberto S. Sanchez**, **Connie B. Chang**, **Diane Bimczok**, **James Wilking**, "Granular Matrigel: restructuring a trusted extracellular matrix material for improved permeability," *Biomedical Materials*, June 2022, 17(4):045020. 22-017.

Bjarnsholt, Thomas, Marvin Whiteley, Kendra P. Rumbaugh, **Philip S. Stewart**, Peter O. Jensen, Niels Frimodt-Moller, "The importance of understanding the infectious microenvironment," *The Lancet Infectious Diseases*, 2022, 22(3):e88-e92. 22-018.

Peng, Mu, Dongyu Wang, Lauren M. Lui, Torben Torben Nielsen, Renmao Tian, Megan L. Kempher Xuanyu Tao, Chongle Pan, Romy Chakraborty, Adam M. Deutschbauer, Michael P. Thorgersen, Michael W. W. Adams, **Matthew W. Fields**, Terry C. Hazen, Adam P. Arkin, Aifen Zhou, Joshing Zhou, "Genomic features and pervasive negative selection in *Rhodanobacter* strains isolated from nitrate and heavy metal contaminated aquifer," *Environ Microbiol*, February 2022, 10(1): e02591-21. 22-019.

Fernandes-Martins, Maria C., Lisa M. Keller, Mason Munro-Ehrlich, **Kathryn R. Zimlich**, **Madelyn K. Mettler**, Alexis M. England, Rita Clare, Kevin Surya, Everett L. Shock, Daniel R. Collman, Eric S. Boyd, "Ecological dichotomies arise in microbial communities due to mixing of deep hydrothermal waters and atmospheric gas in a circumneutral hot spring," *Applied and Environ Microbiol*, 2022, 87(23): e01598-21. 22-020.

Krunkenberg, Viola, **Nicholas Reichart**, Rachel L. Spietz, **Roland Hatzenpichler**, "Microbial community response to polysaccharide amendment in anoxic hydrothermal sediments of the Guaymas Basin," *Front Microbiol*, 2021, 12: 763971. 22-021.

Goodman, Candace, **Katrina N. Lyon**, Aitana Scotto, Cyra Smith, Thomas A. Sebrell, Andrew B. Gentry, Ganesh Bala, Gary D. Stoner, **Diane Bimczok**, "A high-throughput metabolic microarray assay reveals antibacterial effects of black and red raspberries and blackberries against *Helicobacter pylori* infection," *Antibiotics*, 2021, 10(7):845. 22-022.

Reichart, Nicholas J., Robert M. Bowers, Tanja Woyke, **Roland Hatzenpichler**, "Metagenomes and metagenome-assembled genomes from substrate-amended hot spring sediment incubations from Yellowstone National Park," *Environ Microbiol*, 2022, 11(4): e01065-21. 22-023.

Mettler, Madelyn K., Ceth W. Parker[±], Kasthuri Venkateswaran[±], Brent M. Peyton, "
Antimicrobial Coating Efficacy for Prevention of Pseudomonas aeruginosa Biofilm Growth on ISS Water System Materials," *Front Microbiol*, 2022, 13:874236. 22-024.

Bodle, Kylie B., **Madeline R. Pernat[^]**, **Catherine M. Kirkland**, "Pharmaceutical sorption to lab materials may overestimate rates of removal in lab-scale bioreactors," *Water, Air, Soil Pollution*, 2022, 233:505. 22-025.

Parker, Albert E., **Lindsey Miller**, **Jacob Adams[±], Charles Pettigrew**, **Kelli Buckingham-Meyer**, Jennifer Summers, Andres Christen, **Darla Goeres**, "Imaging and plate counting to quantify the effect of an antimicrobial: A case study of a photo-activated chlorine dioxide treatment," *J App Microbiol*, December 2022, 133(6):3413-3423. 22-026.

Espinal, Michael[^], **Seth Kane**, **Cecily Ryan**, **Adrienne Phillips**, **Chelsea Heveran**, "Evaluation of the bonding properties between low-value plastic fibers treated with microbially-induced calcium carbonate precipitation and cement mortar," *Construct Build Mats*, November 2022, 357:129331. 22-027.

Sauer, Karin, Paul Stoodley, **Darla M. Goeres**, Luanne Hall-Stoodley, Mette Burmølle, **Philip S. Stewart**, Thomas Bjarnsholt, "The biofilm life cycle: expanding the conceptual model of biofilm formation," *Nature Rev Microbiol*, August 2022, 20:608-620. 22-028.

Allkja, Jontana, **Darla M. Goeres**, Andrea S. Azevedo, Nuno F. Azevedo, "Interactions of microorganisms within a urinary catheter polymicrobial biofilm model," *Biotechnol Bioeng*, September 2022, 120(1):239-249. 22-029.

Beck, Ashley E., Kathryn Pintar, Ashley Schrammeck, Timothy Johnson, Alissa Bleem, **Martina Du**, William R. Harcombe, Hans C. Bernstein, **Jeffrey J. Heys**, Tomas Gedeon, **Ross P. Carlson**, "Environment constrains fitness advantages of division of labor in microbial consortia engineered for metabolite push or pull interactions," *mSystems*, 7(4): e00051-22. 22-030.

Weaver, Alan J., Jr., **Timothy R. Borgogna**, Galen O'Shea-Stone, Tami R. Peters, Valérie Copié, Jovanka Voyich, and Martin Teintze,"18β-Glycyrrhetinic acid induces metabolic changes and reduces *Staphylococcus aureus* bacterial cell-to-cell interactions," *Antibiotics*, 2022, 11(6): 781. 22-031.

Anoy, Md Monzurul Islam, Suzanne Gelston, Abdelrhman Mohamed, Laure Flurin, Yash S. Raval, Kerryl Greenwood-Quaintance, Robin Patel, **Zbigniew Lewandowski**, "Hypochlorous acid produced at the counter electrode inhibits catalase and increases bactericidal activity of a hydrogen peroxide generating electrochemical bandage," *Bioelectrochem*, December 2022, 148:108261. 22-032.

Jankauski, Mark, **Cailin Casey**, **Chelsea Heveran**, Stephen Buchmann, "Carpenter bee thorax vibration and force generation inform pollen release mechanisms during floral buzzing," *Sci Rep*, August 2022, 12:12654. 22-033.

Kane, Seth, Aksiin Storer, Wei Xu, **Cecily Ryan**, Nicolas P. Stadie, "Biochar as a renewable substitute for carbon black in lithium-ion battery electrodes," *ACS Sustainable Chem Eng*, September 2022, 10(37): 12226-12233. 22-034.

Hislop, Brady D., C. Devin, R.K. June, **Chelsea M. Heveran**, "Subchondral bone structure and synovial fluid metabolism are altered in injured and contralateral limbs 7 days after non-invasive joint injury in skeletally-mature C57BL/6 mice," *Osteoarthr Cart*, December 2022, 30(12):1593-1605. 22-035.

Johnson, Thea, Bryan Tegner Jacobson, Kerri Jones, Cassie Mosdal, Steve Jones, Maia Vitkovic, Sam Kruppenbacher, Andy Sebrell, **Diane Bimczok**, "Transfer and persistence of bovine immunoglobulins in lambs fed a colostrum replacer," *Vet Record*, November 2022, 191(10):e1974. 22-036.

Janicki, Joseph C., Matthew C. Egloff, **Roberta Amendola**, **Cecily A. Ryan**, Dilpreet S. Bajwa, Alexey Dynkin, Douglas S. Cairns, "Formability characterization of fiber reinforced polymer composites using a novel test method," *J Testing Eval*, 2022, 50(2):1140-1154. 22-037.

Loveday, Emma K., **Humberto S. Sanchez**, **Mallory M. Thomas**, **Connie Chang**, "Single-cell infection of influenza A virus using drop-based microfluidics," *Microbiol Spectrum*, 2022, 10(5): e00993-22. 22-038.

Zath, Geoffrey K., Ralph A. Sperling, **Carter W. Hoffman**, **Dimitri Bikos**, **Reha Abbasi**, Adam R. Abate, David A. Weitz, **Connie Chang**, "Rapid parallel generation of a fluorescently barcoded drop library from a microtiter plate using the plate-interfacing parallel encapsulation (PIPE) chip," *Lab on a Chip*, 2022, 23: 4735-4745. 22-039.

Arbogast, James W. ‡, Lori D. Moore, Megan DiGiorgio, Greg Robbins, Tracy L. Clark, T., Maria F. Thompson, Pamela T. Wagner, John M. Boyce, **Albert E. Parker**, "The impact of automated hand hygiene monitoring with and without complementary improvement strategies on performance rates," *Infection Control & Hospital Epidemiology*, 2022, 44(4): 638-642. 22-041.

Parker, Albert E., Alexander G. Dimitrov, "Symmetry-breaking bifurcations of the information bottleneck and related problems," *Entropy*, 2022, 24(9): 1231. 22-042.

Kohtz, Anthony J., **Zackary J. Jay**, **Mackenzie M. Lynes**, Viola Krukenberg, **Roland Hatzenpichler**, "Culexarchaeia, a novel archaeal class of anaerobic generalists inhabiting geothermal environments," *ISME Comm*, 2022, 2(86): s43705-022-00175-8. 22-043.

Chadwick, Grayson L, Connor T. Skennerton, Rafael Laso-Pérez, Andy O. Leu, Daan R. Speth, Hang Yu, Connor Morgan-Lang, **Roland Hatzenpichler**, Danielle Goudeau, Rex Malmstrom, William J. Brazelton, Tanja Woyke, Steven J. Hallam, Gene W. Tyson, Gunter Wegener, Antje Boetius, Victoria J. Orphan, "Comparative genomics reveals electron transfer and syntrophic mechanisms differentiating methanotrophic and methanogenic archaea," *PLoS Biology*, 2022, 20(1): e3001508. 22-044.

Arias, C.A., D. Istenic, **Otto Stein**, X. Zhai, R. Kilian, I. Vera-Puerto, H. Brix, "Effects of effluent recycle on treatment performance in a vertical flow constructed wetland," *Ecol Eng*, 2022, 180:106675. 22-045.

2023 Publications

Vélez Justiniano[±], Yo-Ann, **Darla M. Goeres**, **Elizabeth L. Sandvik**, **Birthe Veno Kjellerup**, Tatyana A. Sysoeva, Jacob S. Harris, **Stephan Warnat**, **Matthew McGlennen, Christine M. Foreman,** Jiseon Yang, Wenyan Li, Chelsi D. Cassilly, Katelyn Lott, Lauren E. HerrNeckar "Mitigation and use of biofilms in space for the benefit of human space exploration," *Biofilm*, 2023, 5:100102. 23-001.

Villa, F., N. Ludwig, S. Mazzini, L. Scaglioni, A.L. Fuchs, B. Tripet, V. Copié, **Philip S. Stewart**, F. Cappitelli, "A desiccated dual-species subaerial biofilm reprograms its metabolism and affects water dynamics in limestone," *Sci Total Environ,* 2023, 868:161666. 23-002.

Goemann, Calvin L.C., Royce Wilkinson, Willam Henriques, **Huyen Bui**, **Hannah M. Goemann**, **Ross P. Carlson**, Sridhar Viamajala, **Robin Gerlach**, Blake Wiedenheft, "Genome sequence, phylogenetic analysis, and structure-based annotation reveal metabolic potential of *Chlorella* sp. SLA-04," *Algal Res,* 2023, 69:102943. 23-003.

Peach, Jesse T., **Rebecca C. Mueller**, **Dana J. Skorupa**, **Margaux M. Mesle**, Sutton Kanta, Eric Boltinghouse, Bailey Sharon, Vaerie Copié, Brian Bothner, **Brent M. Peyton**, "Longitudinal analysis of the Five Sisters hot springs in Yellowstone National Park reveals a dynamic thermoalkaline environment," *Sci Rep*, 2023, 12:18707. 23-004.

Lynes, **Mackenzie M.,** Krukenberg**, Viola**, **Jay, Zackary J.**, **Kohtz, Anthony J**., Gobrogge, Christine A., **Spietz, Rachel L.**, **Hatzenpichler, Roland**, "Diversity and function of methyl-coenzyme M reductase-encoding archaea in Yellowstone hot springs revealed by metagenomics and mesocosm experiments," *ISME Comm*, March 2023, 3:22. 23-005.

Ryder, Marcia, **Elinor deLancey-Pulcini**, **Albert E. Parker**, **Garth James**, "Bacterial transfer and biofilm formation in needleless connectors in a clinically simulated in vitro catheter model," *Infect Cont Hosp Epidemiol*, April 2023,1-9. 23-006.

Kong, Wentao, Yuanchao Qian, **Philip S. Stewart**, Ting Lu, "De novo engineering of a bacterial lifestyle program," *Nature Chem Biol*, 2023, 19: 488–497. 23-007.

Heveran, Chelsea M., J.D. Boerckel, "Osteocyte remodeling of the lacunar-canalicular system: What's in a name?", *Current Osteoporosis Reports*, 2023, 21:11–20. 23-008.

Sharp, Julia L., **Albert E. Parker, Martin A. Hamilton**, "Calculating the limit of detection for a dilution series," *J Microbiol Methods*, May 2023, 208:106723. 23-009.

Wiegand, Tanner, Royce Wilkinson, Andrew Santiago-Frangos, **Mackenzie Lynes**, **Roland Hatzenpichler**, Blake Wiedenheft, "Functional and phylogenetic diversity of Cas10 proteins," *CRISPR Journal*, April 2023, 6(2):152-162. 23-010.

Allen, Chris R., **M.D. Burr**, **Anne K. Camper**, J.J. Moss, **Otto R. Stein**, "Seasonality, C:N ratio and plant species influence on denitrification and plant nitrogen uptake in treatment wetlands," *Ecol Eng*, 2023, 191:106946. 23-011.

Mettler, Madelyn K., **Hannah M. Goemann**, **Rebecca C. Mueller**, Oscar A. Vanegas, Gabriela Lopez, Nitin Singh, **Kasthuri Venkateswaran[±], Brent M. Peyton**, "Development of Martian saline seep models and their implications for planetary protection," *Biofilm*, 2023, 5:100127. 23-012.

Vahidi, Ghazal, **Maya Moody[^]**, **Hope D. Welhaven[^]**, **Leah Davidson**, Taraneh Rezaee, Ramina Behzad, Lamya Karim, Barbara A. Roggenbeck, Seth T. Walk, Stephen A. Martin, Ronald K. June, **Chelsea M. Heveran**, "Germ-free C57BL/6 mice have increased bone mass and altered matrix properties but not decreased bone fracture resistance," *J Bone Mineral Res*, 2023, jbmr.4835. 23-013.

Platt, George, **Katherine J. Davis[#], Hannah D. Schweitzer**, **Heidi J. Smith**, **Matthew W. Fields**, **Elliott P. Barnhart**, **Robin Gerlach**, "Algal amendment enhances biogenic methane production from coals of different thermal maturity," *Front Microbiol*, March 2023, 14:1097500. 23-014.

[±] Industrial or Federal Agency co-author
*Previous Visiting Researcher
[#] Previous staff/faculty
[^] Undergraduate Student

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RESEARCH:
PRESENTATIONS
June 2022–May 2023

Adrienne Arnold, Graduate Student. “Metabolic Modeling of Lipid- and Starch- Accumulating Microalgae in a High Alkalinity Cultivation System” Algae Biomass Summit 2022-10-03 Remote Invited talk.

Al Parker, Faculty. “Standardized Biofilm Methods” Montana Biofilm Meeting 2022-07-11 Bozeman, MT Invited talk.

Al Parker, Faculty. “Statistical considerations in image analysis” Montana Biofilm Meeting 2022-07-12 Bozeman, MT Invited talk.

Al Parker, Faculty. “Tools in the Toolbox for Assessing Effectiveness of Sanitation Chemistries Against Biofilms” Data-Driven Sanitation Chemistry Selection, IAFP 2022-08-02 Pittsburgh, PA Invited talk.

Al Parker, Faculty. “Statistics for Image Analysis” 3M Technical Forum 2022-08-31 Remote Invited talk.

Al Parker, Faculty. “Limits of Detection in Microbiology” 3M Technical Forum 2022-09-22 Remote Invited talk.

Al Parker, Faculty. “Control strategies for bacterial biofilms – the need for standard methods?” Asia Pacific Biofilms 2022 2022-10-18 Guangzhou, China Invited talk.

Al Parker, Faculty. “The Effect of a Prospective Intervention Program with Automated Monitoring on Hand Hygiene Performance in Long-term and Acute Care Units at a Veteran Affairs Medical Center” Infectious Diseases Week 2022-10-19 Washington, D.C. Invited talk.

Amit Acharjee, Graduate Student. “Effect of Engineered Grain Boundaries & Surface Finish on Microbiologically Influenced Corrosion (MIC) of Copper 101” Montana Biofilm Meeting 2022-07-12 Bozeman, MT Poster.

Amit Acharjee, Graduate Student. “Effect of Extrinsic Material Properties of Copper on Microbiologically Influenced Corrosion (MIC)” Euro Corr 2022 Conference 2022-08-29 Berlin, Germany Invited talk.

Amit Acharjee, Graduate Student. “Effect of Extrinsic Material Properties of Copper on Microbiologically-Influenced Corrosion (MIC)” NSF DDMD All Investigator Meeting at MSU 2022-10-20 Bozeman, MT Invited talk.

Brian Pettygrove, Graduate Student. “Investigating potential microbial community interactions in alkaline production systems” MCB-RIP presentations 2022-10-08 Bozeman, MT Invited talk.

Darla Goeres, Faculty. “Biofilm Standard Test Methods: Establishing the Path to Anti-biofilm Products in the Marketplace” Barcelona Biofilm Summit Virtual Conference 2022-11-10 Barcelona, Spain Invited talk.

Darla Goeres, Faculty. “Developing criteria for biofilm management on the ISS” NASA Technical Interchange Meeting (TIM) 2023-02-23 Remote Invited talk.

Ethan Viles, Graduate Student. “Using fungal mycelium as scaffold for biomineralized building materials” Montana Biofilm Meeting 2022-07-12 Bozeman, MT Poster.

Ethan Viles, Graduate Student. “Fungal Mycelium as a Scaffold for Biomineralized Building Materials” Materials Research Society Fall Meeting 2022-11-30 Boston, MA Invited talk.

Garth James, Faculty. “Medical biofilms laboratory oral biofilm research and testing” Antibiotics 2023 2023-03-03 Remote Invited talk.

Gauri Gaur, Graduate Student. “Defining a new role for complement in the pathogenesis of S. aureus” MSU MCB Research in Progress Seminar 2023-04-21 Bozeman, MT Invited talk.
Haley Ketteler, Graduate Student. “Sensing Slime: Microfabricated Sensors to Detect Biofilm in Space Applications” Montana Biofilm Meeting 2022-07-14 Bozeman, MT Invited talk.

Haley Ketteler, Graduate Student. “A Sensor Driven Approach for Monitoring Biofilms under the Influence of Microgravity” American Society for Gravitational and Space Research Annual Meeting 2022-11-11 Houston, TX Invited talk.

Huyen Bui, Graduate Student. “Bacterial-Algal Interactions in High pH-High Alkalinity Algal Cultivation” JGI User Meeting 2022-08-29 Remote Invited talk.

Huyen Bui, Graduate Student. “Bacterial-Algal Interactions in High pH-High Alkalinity Algal Cultivation” CBE Seminar Series 2022-09-03 Bozeman, MT Invited talk.

Huyen Bui, Graduate Student. “Characterization of the Microbiome in High pH Algal Cultures” Algae Biomass Summit 2022-10-03 Remote Invited talk.

Isaac Miller, Graduate Student. “Phycosome activity during the diel cycle” Montana Biofilm Meeting 2022-07-12 Bozeman, MT Poster.

Isaac Miller, Graduate Student. “The phycosome of an alkalitolerant microalgae” The Arctic University of Norway UiT Seminar 2022-08-01 Tromso, Norway Invited talk.

Isaac Miller, Graduate Student. “Bacterial community dynamics during successive outdoor algae cultivation from late summer to fall 18th International Society on Microbial Ecology (ISME18) 2022-08-01 Lausanne, Switzerland Poster.

Isaac Miller, Graduate Student. “Complement interactions with nascent S. aureus biofilms” MCB-RIP presentations 2022-10-08 Bozeman, MT Invited talk.

Isaac Miller, Graduate Student. “Phycosome activity during the diel cycle” Algae Biomass Summit 2022-10-03 Remote Invited talk.

Katrina Lyon, Graduate Student. “Characterizing the organoid luminal microenvironment for studies of gastric mucus dynamics and pH regulation” ITHS Translational Science Expo 2022-09-30 Seattle, WA Invited talk.

Katrina Lyon, Graduate Student. “Bioengineered gastric mucus generated in human organoids exhibits viscoelastic properties and inhibits H. pylori motility in vitro” AGA James W. Freston Conference 2022-10-07 Washington, D.C. Invited talk.

Kaylin Clark, Undergraduate Student. “Durability of microbially produced calcium carbonate adhesives” Montana Biofilm Meeting 2022-07-12 Bozeman, MT Poster.

Kelli Buckingham-Meyer, Faculty. “Standardized Biofilm Methods” Montana Biofilm Meeting Workshop 2022-07-11 Bozeman, MT Invited talk.

Kelli Buckingham-Meyer, Faculty. “Biofilm Harvesting Methods: An Overlooked Steps” Montana Biofilm Meeting 2022-07-12 Bozeman, MT Poster.

Kelli Buckingham-Meyer, Faculty. “Standardized Biofilm Methods” Asia Pacific Biofilms 2022 2022-10-18 Guangzhou, China Invited talk.

Kylie Bodle, Graduate Student. “Pharmaceutical effects on aerobic granular sludge morphology and treatment capacity” Montana Biofilm Meeting 2022-07-12 Bozeman, MT Poster.

Kylie Bodle, Graduate Student. “Pharmaceutical effects on aerobic granular sludge: Morphology and treatment capacity” American Water Resources Association: MT Chapter Conference 2022-10-12 Butte, MT Invited talk.

Kylie Bodle, Graduate Student. “Effects of three model pharmaceuticals on aerobic granular sludge morphology, communities, and treatment capacity” International Water Association Biofilms Conference 2022-12-06 Phuket, Thailand Invited talk.

Madelyn Mettler, Graduate Student. “Influence of antimicrobial coatings on biofilm accumulation of multidomain ISS wastewater isolates” Montana Biofilm Meeting 2022-07-12 Bozeman, MT Poster.

Madelyn Mettler, Graduate Student. “Use of antimicrobial coatings to prevent multispecies multidomain biofilm growth of ISS isolates in wastewater system” International Astronautical Congress 2022-09-22 Paris, France Invited talk.

Madelyn Mettler, Graduate Student. “Can antimicrobial coatings reduce multispecies, multidomain biofilm growth of ISS isolates?” American Society for Gravitational and Space Research Annual Meeting 2022-11-10 Houston, TX Invited talk.

Phil Stewart, Faculty. “Is There a Universal Biofilm Defense?” Montana Biofilm Meeting 2022-07-13 Bozeman, MT Invited talk.

Phil Stewart, Faculty. “Adsorbed Host Proteins Mediate Neutrophil Function on an Abiotic Surface” Costerton Biofilm Center 2022-07-13 Copenhagen, Denmark Invited talk.

Phil Stewart, Faculty. “Search for a Shared Genetic or Biochemical Basis for Biofilm Tolerance to Antibiotics across Bacterial Species” International Caparica Conference in Antibiotic Resistance 2022-09-05 Costa da Caparica, Portugal Invited talk.

Phil Stewart, Faculty. “Sorbed Host Proteins Mediate Neutrophil Adhesion, Motility, and Discovery of Staphylococcus aureus on an Abiotic Surface” American Society for Microbiology Biofilms 2022 Conference 2022-11-17 Charlotte, NC Invited talk.

Phil Stewart, Faculty. “Biofilms vs Antimicrobials” ASM Microbe Meeting 2023-06-16 Houston, TX Invited talk.

Sobia Anjum, Graduate Student. “Ureolytically induced calcium carbonate composites as bioadhesives” Montana Biofilm Meeting 2022-07-13 Bozeman, MT Invited talk.

Sobia Anjum, Graduate Student. “Ureolytically induced calcium carbonate composites as natural adhesives” Materials Research Society Fall Meeting 2022-12-06 Boston, MA Invited talk.

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RESEARCH:

CBE Affiliated Faculty and Their Specialties, 2022–2023

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
Amanda Hohner	Civil Engineering	Water quality; drinking water treatment
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
Chris Jones	Center for Biofilm Engineering	Biofilm interaction with surfaces
Christine Foreman	Chemical & Biological Engineering	Microbial ecology in cold temperature environments
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
Emma Loveday	Microbiology & Cell Biology	Virology
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
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
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

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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EDUCATION:

Undergraduate Students: Summer 2022, Fall 2022, Spring 2023

*Graduating ‡Native American

1.	Albrecht, Emma (Fields)	F	Microbiology & Cell Biology	Stillwater, MN
2.	Basile, Madison (Lauchnor/Stein)	F	Civil Engineering	Missoula, MT
3.	Bomber, Allyson (Phillips)	F	Civil Engineering	Corvallis, OR
4.	*Brown, Noah (Warnat)	M	Mechanical & Industrial Engineering	Golden, CO
5.	Buckner, Elizabeth (Goeres)	F	Microbiology & Cell Biology	Kalispell, MT
6.	Buggy-Agresti, Eli (Wilking)	M	Chemical & Biological Engineering	Sacramento, CA
7.	*Burke, Aspen (Foreman)	F	Chemical & Biological Engineering	Windsor, MA
8.	Bruhl, Katerina (Fields)	F	Microbiology & Cell Biology	Maple Valley, WA
9.	Carey, Taylor (Peyton)	F	Chemical & Biological Engineering	Wasilla, AK
10.	Castro, Allison (Peyton)	F	Microbiology & Cell Biology	Erie, CO
11.	*Cummings, Atticus (Heveran)	M	Directed Interdisciplinary Studies	Bozeman, MT
12.	Dauenhauer, Lexia (Heveran)	F	Chemical & Biological Engineering	Butte, MT
13.	DeMarco, Jamie (Chang)	F	Chemical & Biological Engineering	Billings, MT
14.	Diehl, Lydia (Peyton)	F	Ecology	Bozeman, MT
15.	Evans, Emily (Espinosa-Ortiz/Gerlach)	F	Microbiology & Cell Biology	Fort Shaw, MT
16.	Faber, Jessica (Kirkland)	F	Civil Engineering	Parker, CO
17.	Greenberg, Abigail (James/Huth)	F	Microbiology & Cell Biology	Billings, MT
18.	Haab, Amanda (Fields)	F	Microbiology & Cell Biology	Helena, MT
19.	Harms, Kaelyn (Phillips)	F	Civil Engineering	Eagle, ID
20.	Hickethier, Micah (Stewart)	F	Chemical & Biological Engineering	Kalispell, MT
21.	*Jackson, Lauren (Warnat)	F	Mathematical Sciences	Sedalia, CO
22.	Jackson, Ruby (Warnat/Foreman)	F	Mechanical & Industrial Engineering	Kalama, WA
23.	*Johnson, Lura (Lauchnor)	F	Civil Engineering	Kenne Valley, NY
24.	Keim, Emelia (James)	F	Microbiology & Cell Biology	Moscow, ID
25.	Kirkpatrick, Tess (Fields)	F	Chemistry & Biochemistry	Corrales, NM
26.	Koepke, Jack (Goeres)	M	Chemical & Biological Engineering	Missoula, MT
27.	Krysiak, Nicole (Foreman)	F	Chemistry & Biochemistry	Arvada, CO
28.	Larson, Madison (Chang/Phillips)	F	Chemical & Biological Engineering	Golden, CO
29.	Lord, Alexa (Phillips)	F	Civil Engineering	Lakewood, CO
30.	Miller, Kyle (Espinosa-Ortiz/Gerlach)	M	Ecology	Kalispell, MT
31.	*Miller, Madeleine (Warnat)	F	Mechanical & Industrial Engineering	Wasilla, AK
32.	Moody, Maya (Heveran)	F	Chemistry & Biochemistry	Bozeman, MT
33.	Myxter, Alexander (Peyton)	M	Land Resources and Environmental Sciences	Fort Collins, CO
34.	*Nelson, Genevieve (Stewart/Livinghouse)	F	Chemistry & Biochemistry	Corvallis, OR
35.	Peterson, Natasha (Peyton)	F	Microbiology & Cell Biology	Helena, MT
36.	Rasch, Rory (Warnat)	M	Mechanical & Industrial Engineering	Bozeman, MT
37.	Renner, Konrad (James)	M	Microbiology & Cell Biology	Eagle River, AK
38.	Ritter, Kadin (Warnat)	M	Mechanical & Industrial Engineering	Golden, CO
39.	*Rupp, Rachael (Fields)	F	Chemical & Biological Engineering	Laurel, MT
40.	*Rux, Kylee (Heveran)	F	Civil Engineering	Billings, MT
41.	*Salsburg, Nathan (Goeres)	M	Mechanical & Industrial Engineering	Lake Oswego, OR
42.	*Schafer, Kylee (Goeres)	F	Microbiology & Cell Biology	Billings, MT
43.	Schoderbek, Samuel (Gerlach)	M	Civil Engineering	Bend, OR
44.	Schultz, Marika (Phillips)	F	Civil Engineering	Bozeman, MT
45.	*Teska, Christy (Foreman)	F	Chemical & Biological Engineering	Stow, MA
46.	Watson, Steven (Heveran)	M	Chemical & Biological Engineering	Barrington, NH
47.	*Wearmouth, Antonia (Stein/Lauchnor/Phillips)	F	Civil Engineering	North Vancouver, Canada
48.	Yatso, Marcella (Kirkland)	F	Civil Engineering	Shorewood, WI

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Undergraduates Summary: 2022–2023

Department	Male	Female	Total
Chemical & Biological Engineering	3M	8F	11
Chemistry & Biochemistry		4F	4
Civil Engineering	1M	10F	11
Directed Interdisciplinary Studies (Honors College)	1M		1
Ecology	1M	1F	2
Land Resources and Environmental Sciences	1M		1
Mathematical Sciences		1F	1
Mechanical & Industrial Engineering	4M	2F	6
Microbiology & Cell Biology	1M	10F	10
Totals	**5M**	**35F**	**48**

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EDUCATION:

Graduate Students: Summer 2022, Fall 2022, Spring 2023

‡ Native American *Received degree

Masters Candidates

1.	Arpali, Handenur (Warnat/Foreman)	F	Chemical & Biological Engineering	Istanbul, Turkey
2.	*Arnold, Adrienne (Carlson)	F	Microbiology & Cell Biology	Charleston, WV
3.	Bayliss, Bennet (Loveday)	M	Chemical & Biological Engineering	Montrose, CO
4.	Bedey, Kayla (Phillips/Kirkland)	F	Civil Engineering	Madisonville, LA
5.	Brush, Kristen (Stein)	F	Civil Engineering	Delray Beach, FL
6.	*Collins, Daniel (Warnat/Foreman)	M	Mechanical & Industrial Engineering	Palmer Alaska, AK
7.	*Delwiche, Jenna (Phillips/Lauchnor)	F	Civil Engineering	Portland, OR
8.	Dorian, Hudson (Phillips/Khosravi)	M	Civil Engineering	Fresno, CA
9.	*Durojaye, Olayinka (Kirkland)	F	Civil Engineering	Benin City, Nigeria
10.	Keskin, Yagmur (Peyton/Fields)	F	Chemical & Biological Engineering	Tire, Turkey
11.	Kessler, Kendall (Carlson)	F	Chemical & Biological Engineering	Kalispell, MT
12.	Kettler, Haley (Foreman/Warnat)	F	Electrical & Computer Engineering	Pierre, SD
13.	*Lindsay, Travis (Chang)	M	Chemical & Biological Engineering	Eagle, ID
14.	Lyon, Katrina (Wilking)	F	Microbiology & Cell Biology	Highwood, IL
15.	Palen, Thomas (Warnat)	M	Mechanical & Industrial Engineering	Kenne, NY
16.	*Ritu, Tasnim Sultana (Kirkland)	F	Civil Engineering	Joypurhat, Bangladesh
17.	Vallie, James (Peyton)	M	Chemical & Biological Engineering	Crow Agency, MT
18.	Ugur, Elif (Heveran/Phillips)	F	Mechanical & Industrial Engineering	Sinop, Turkey

PhD Candidates

1.	Acharjee, Amit (Amendola/Fields)	M	Mechanical & Industrial Engineering	Dhaka, BANG
2.	Andreas, Elizabeth (Carlson)	F	Mathematical Sciences	Evanston, WY
3.	Anjum, Sobia (Gerlach)	F	Civil Engineering	Punjab, Pakistan
4.	Ayotte, Stephanie (Lauchnor/Stein)	F	Civil Engineering	Saco, ME
5.	Aviles Zuniga, Tadeo (Loveday)	M	Computer Science	Burbank, CA
6.	Bodle, Kylie (Kirkland)	F	Civil Engineering	Camano Island, WA
7.	Boles, Bruce (Foreman)	M	Chemical & Biological Engineering	Knoxville, TN
8.	Brown, Kenna (Heveran)	X	Mechanical & Industrial Engineering	Grand Junction, CO
9.	Casey, Cailin (Heveran)	F	Mechanical & Industrial Engineering	Concord, NH
10.	Christian, William (Hatzenpichler)	M	Chemistry & Biochemistry	Grand Rapids, MT
11.	Crandall, Jennifer (Fields/Hatzenpichler)	F	Microbiology & Immunology	Wallingford, CT
12.	Demeritte, Amethyst (Stewart/Livinghouse)	F	Chemistry & Biochemistry	New Providence, Bahamas
13.	Dang, Aria (Foreman)	F	Molecular Biosciences	Houston, TX
14.	Du, Martina (Carlson)	F	Chemical & Biological Engineering	Kent, WA
15.	*Fredrikson, Jacob (Chang)	M	Chemical & Biological Engineering	Puyallup, WA
16.	Garner, Madeline (Foreman)	F	Molecular Biosciences	Cookeville, TN
17.	Gattiker, Jasper (Bimczok)	M	Microbiology & Cell Biology	Watkinsville, GA
18.	Gaur, Gauri (Stewart)	F	Microbiology & Cell Biology	Gurgaon, India
19.	Griffin, Gabriel (Espinosa-Ortiz/Gerlach)	M	Chemical & Biological Engineering	Hancock, MI
20.	Goemann, Calvin (Gerlach)	M	Microbiology & Cell Biology	Isanti, MN
21.	Goemann, Hannah (Peyton)	F	Microbiology & Cell Biology	Wells, MN
22.	Hoffman, Carter (Chang)	M	Chemical & Biological Engineering	Carisbad, CA
23.	Holcomb, Charles (Gerlach)	M	Chemical & Biological Engineering	Great Falls, MT
24.	Joshi, Pukar (Phillips)	M	Civil Engineering	Morang, Nepal
25.	Kaffer, John (Peyton)	M	Microbiology & Cell Biology	Madison, AL
26.	Kane, Seth (Ryan/Phillips)	M	Mechanical & Industrial Engineering	Fairbanks, AK
27.	Kohtz, Anthony (Hatzenpichler)	M	Chemistry & Biochemistry	Omaha, NE

28.	Knutson, Keigan (Stewart)	M	Microbiology & Cell Biology	Kalispell, MT
29.	Koenig, Heidi (Stewart/Livinghouse)	F	Chemistry & Biochemistry	Effie, MB
30.	Koepnick, Hannah (Peyton)	F	Chemical & Biological Engineering	Sherman, TX
31.	Kugbajor, El-Freda (Amendola)	F	Mechanical & Industrial Engineering	Kumasi, Gana
32.	Lynes, MacKenzie (Hatzenpichler)	F	Chemistry & Biochemistry	Cleveland, OH
33.	Opp, Breuklyn (Gerlach)	X	Chemical & Biological Engineering	Charles City, IA
34.	*Pratt, Shawna (Chang)	F	Chemical & Biological Engineering	Miles City, MT
35.	Marquis, James (Fields)	M	Microbiology & Cell Biology	Mill Valley, CA
36.	Mettler, Madelyn (Peyton)	F	Chemical & Biological Engineering	Littleton, CO
37.	*McGlennen, Matthew (Warnat/Foreman)	M	Mechanical & Industrial Engineering	Edina, MN
38.	Mikesell, Logan (Stewart)	M	Chemistry & Biochemistry	Onsted, MI
39.	Miller, Isaac (Fields)	M	Microbiology & Cell Biology	Helena, MT
40.	Mozaffari, Arash (Stein/Lauchnor)	M	Civil Engineering	Qazin, Iran
41.	Neubauer, Michael (Warnat)	M	Mechanical & Industrial Engineering	Rogers, MN
42.	Nupp, Sylvia (Hatzenpichler)	F	Chemistry & Biochemistry	Russellville, AK
43.	*Sanchez, Humberto (Chang)	M	Chemical & Biological Engineering	Corona, CA
44.	Schaible, George (Hatzenpichler)	M	Chemistry & Biochemistry	Missoula, MT
45.	Shikany, Johnathan (Peyton)	M	Chemical & Biological Engineering	Bellingham, WA
46.	Stanley-Thompson, Maribelle (Wilking)	F	Chemical & Biological Engineering	Corvallis, OR
47.	Strupulis, Chloe (Wilking)	F	Chemical & Biological Engineering	Anchorage, AK
48.	Thomas, Mallory (Chang)	F	Microbiology & Cell Biology	Elkhart, IN
49.	Thornton, Isaak (Wilking)	M	Mechanical & Industrial Engineering	Great Falls, MT
50.	Trimmer, Stavros (Foreman)	M	Molecular Biosciences	Albuquerque, NM
51.	Willett, Matthew (Kirkland)	M	Chemical & Biological Engineering	Puyallup, WA
52.	Willis, Madelyne (Foreman)	F	Land Resources & Environmental Sciences	Atlanta, GA
53.	Wood, Jessica (Fields)	F	Microbiology & Cell Biology	Lafayette, IN
54.	Vahidi, Ghazal (Heveran)	F	Mechanical & Industrial Engineering	Gorgan, Iran
55.	Viles, Ethan (Heveran/Espinosa-Ortiz)	M	Mechanical & Industrial Engineering	Veradale, WA
56.	Zimlich, Kathryn (Fields)	F	Microbiology & Cell Biology	Dublin, OH

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EDUCATION:
Graduate Students, 2022–2023

20: Chemical & Biological Engineering

MS: 5

2 M *Lindsay, Travis: MS, *Chang*
Vallie, James: MS, *Peyton*

3 F Arpali, Handenur: MS, *Warnat*
Keskin, Yagmur: MS, *Peyton*
Kessler, Kendall: MS, *Carlson*

PhD: 15

8 M Boles, Bruce: PhD, *Foreman*
Fredrickson, Jacob: PhD, *Chang*
Griffin, Gabriel: PhD, Espinosa-Ortiz/Gerlach
Hoffman, Carter: PhD, *Chang*
Holcomb, Charles: PhD, *Gerlach*
*Sanchez, Humberto: PhD, *Chang*
Shikany, Jonathan: PhD, *Peyton*
Willett, Matthew: PhD, *Kirkland*

6 F Du, Martina: PhD, *Carlson*
Koepnick, Hannah: PhD, P*eyton*
Mettler, Madelyn: PhD, P*eyton*
*Pratt, Shawna: PhD, *Chang*
Stanley-Thompson, Maribelle: PhD, *Wilking*
Strupulis, Chloe: PhD, *Wilking*

1 X Opp, Breuklyn: PhD, *Foreman*

1: Computer Science

PhD: 1

1 M Aviles Zuniga, Tadeo: PhD, *Loveday*

8: Chemistry & Biochemistry

PhD: 8

4 M Christian, William: PhD, *Hatzenpichler*
Kohtz, Anthony: PhD, *Hatzenpichler*
Mikesell, Logan: PhD, *Stewart/Livinghouse*
Schaible, George: PhD, *Hatzenpichler*

4 F Demeritte, Amethyst: PhD, *Stewart/Livinghouse*
Lynes, Mackenzie: PhD, *Hatzenpichler*
Koenig, Heidi, PhD, *Stewart/Livinghouse*
Nupp, Sylvia, PhD, *Hatzenpichler*

10: 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*
*Durojaye, Olayinka: MS, *Kirkland*
*Ritu, Tasnim Sultana: MS, *Kirkland*

PhD: 5

2 M Mozzaffari, Mohammed: PhD, S*tein/Lauchnor*
Willett, Matthew: PhD, *Kirkland*

3 F Anjum, Sobia: PhD, *Gerlach*
Ayotte, Stephanie: PhD, *Stein*
Bodle, Kylie: PhD, *Kirkland*

1: Electrical & Computer Engineering

MS: 1

1 F Kettler, Haley: MS, *Foreman/Warnat*

1: Land Resources & Environmental Sciences

PhD: 1

1 F Willis, Madelyne: PhD, *Foreman*

1: Mathematical Sciences

PhD: 1

1 F Andreas, Elizabeth: PhD, *Carlson/Gedeon*

12: Mechanical & Industrial Engineering

MS: 3

2 M *Collins, Daniel: MS, *Warnat/Foreman*
Palen, Thomas: MS, *Warnat*

1 F Ugur, Elif: MS, *Heveran/Phillips*

PhD: 9

5 M Amit Acharjee: PhD, *Amendola/Fields*
*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*
Kugbajor, El-Freda: PhD, *Amendol*a
Vahidi, Ghazal: PhD, *Heveran*

1 X Brown, Kenna: PhD, *Heveran*

Continues on next page

14: Microbiology & Cell Biology

MS: 2

2 F *Arnold, Adrienne: MS, *Carlson*
Lyon, Katrina: MS, *Wilking*

PhD: 12

6 M Gattiker, Jasper: PhD, *Bimczok*
Goemann, Calvin: PhD, *Gerlach*
Kaffer, John: PhD, *Peyton*
Knutson, Keigan: PhD, *Stewart*
Marquis, James: PhD, *Fields*
Miller, Isaac: PhD, *Fields*

6 F Crandall, Jennifer: PhD, *Hatzenpichler/Fields*
Gaur, Gauri: PhD, *Stewart*
Goemann, Hannah: PhD, *Peyton*
Thomas, Mallory: PhD, *Chang*
Wood, Jessica: PhD, *Fields*
Zimlich, Kathryn: PhD, *Fields*

2: Molecular Biosciences

PhD: 2

2 F Dang, Aria: PhD, *Foreman*
Garner, Madeline: PhD, *Foreman*
1 M Trimmer, Stavros: PhD, *Foreman*

TOTALS –

Total Grads: 74

Total MS: 18 6 M / 12F
Total PhD: 56 28 M / 26 F / 2 X

Total Male: 34
Total Female: 38
Total Non-Binary: 2

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EDUCATION:

Graduating with advanced degrees: June 2022–June 2023

Adrienne Arnold, MS, Microbiology & Cell Biology, July 2022
Stoichiometric modeling of storage compound metabolism in methanotrophs and green algae

Tasnim Ritu, MS, Civil Engineering, November 2022
Performance of aerobic granular sludge (AGS) to remove poly-perfluoroalkyl substances (PFAS)

Matthew McGlennen, PhD, Mechanical & Industrial Engineering, April 2023
Electrochemical impedance spectroscopy biosensor platform for evaluation of biofilm

Shawna Pratt, PhD, Chemical & Biological Engineering, April 2023
Bacterial cultivation in microscale drops and capsules to resolve singe-cell growth physiology

Calvin Goemann, PhD, Microbiology & Cell Biology, April 2023
Investigating the genomic composition of green algae grown in high alkaline conditions

Travis Lindsay, MS, Chemical & Biological Engineering, May 2023
Single cell encapsulation, detection, and sorting of *pseudomonas* syringae using drop-based microfluidics

Daniel Collins, MS, Mechanical & Industrial Engineering, May 2023
Design and fabrication of an automated soil-water micro-sample extractions system

Sobia Anjum, PhD, Chemical & Biological Engineering, June 2023
Material properties of ureolytically induced calcium carbonate composites

Jenna Delwiche, MS, Environmental Engineering, June 2023
Investigation of microbially induced carbonate precipitation for mitigation of acid mine drainage from coal mining waste

Olayinka Durojaye, MS, Environmental Engineering, June 2023
Title unknown

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EDUCATION:

CBE Seminar Series: Fall 2022

Montana State University, Barnard 108, 4:10 p.m.

Date	Speaker	Affiliation	Title/Topic
Aug 25	No Seminar		
Sept 1	Dr. Huyen Bui	Assistant Research Professor, Chemical & Biological Engineering, CBE, MSU	Bacterial-Algal interactions in high pH - high alkalinity algal cultivation
Sept 8	No Seminar		
Sept 15	Dr. Brandon Briggs	Associate Professor, Department of Biological Sciences, University of Alaska	Microbe-mineral interactions: From extreme environments to biotechnological advances
Sept 22	Sara Toja-Ortega	Postdoctoral Researcher, CBE, MSU, TU Delft	Removal of polymeric substrates from wastewater by aerobic granular sludge technology
Sept 29	Professor Christopher Hernandez	Sibley School of Mechanical and Aerospace Engineering, Cornell University	Microbes and Biomechanics
Oct 6	Dr. Christopher Smith	Nature's Fynd	Sustainable protein production for food applications from a microbe, Fusarium strain flavolapis, isolated from Yellowstone National Park
Oct 13	No Seminar		
Oct 20	Dr. Neerja Zambare	Environmental Molecular Sciences Laboratory, Pacific Northwest National Lab	Calcium carbonate formation by bacteria – nano-scale insights and attempts at combating the ammonium problem
Oct 27	Dr. Jill Mikucki	Associate Professor, Department of Microbiology, University of Tennessee, Knoxville	Cryptic cryospheric habitats: Extremophile refuge and astrobiological analogs
Nov 3	Lan Li Wong *special time 9am (via Webex)	PhD Candidate, Singapore Centre for Environmental Life Sciences Engineering	Surface (S-) layer protein mediates bacterial organization in a key industrial and environmental anammox biofilm
Nov 10	No Seminar		
Nov 17	No Seminar		
Nov 24	No Seminar – Fall Break		
Dec 1	Dr. Anthony Bertagnolli	Senior Research Scientist, Department of Microbiology, Montana State University	Net-spinning caddisflies create denitrifier-enriched niches in montane stream biofilms
Dec 8	No Seminar – Last Week of Classes		
Dec 15	No Seminar – Finals Week		

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EDUCATION:

CBE Seminar Series: Spring 2023

Montana State University, AIH 102, 4:10pm

Date	Speaker	Affiliation	Title/Topic
Jan 19	No seminar – First Week of Classes		
Jan 26	No seminar		
Feb 2 *10 am MST Barnard 126	Dr. Natalia Ivleva	Lecturer, Analytical Chemistry, Technical University of Munich, Germany	Applicability and limitations of Raman microspectroscopy for analysis of microorganisms and biofilms on the single-cell level
Feb 9	No Seminar		
Feb 16	Dr. Danielle Ulrich	Assistant Professor, Ecology, MSU	Plant-microbe interactions influence plant physiology under drought
Feb 23 *9 am MST NAH 337	Dr. Cecilia Burzio	Chalmers University of Technology, Sweden	Removal of micropollutants from wastewater in aerobic granular sludge and activated sludge systems
Mar 2	Colin Gauvin	Assistant Manager, Cryo-EM Facility, Martin Lawrence Lab, Chemistry & Biochem., MSU	Cryo-EM at MSU: From atoms to cells
	Luke Findlay	PhD Student, Martin Lawrence Lab, Chemistry & Biochem., MSU	Structural studies of ribosome hibernation in *Pseudomonas aeruginosa*
Mar 9	No Seminar		
Mar 16	No Seminar – Spring Break		
Mar 23	Dr. Erica McKenzie	Associate Professor, Environmental Engineering, Temple University	An environmental chemist's musings on chemical pollutants in a biological world: case studies of stormwater denitrification and PFAS biouptake
Mar 30 Undergraduate Research Day	Diego Armstrong	Mechanical & Industrial Engineering, Yaofa Li Lab, CBE, MSU	Fabrication of micromodels for analysis of drying and multiphase low in porous media
	Jessica Dewit	Cell Biology & Neuroscience, Diane Bimzcok Lab, CBE, MSU	Mycoplasma ovipneumoniae biofilms contribute to antibiotic resistance and pathogen persistence in the ovine respiratory tract
	Lydia Diehl	Ecology, Brent Peyton Lab, CBE, MSU	Rhizosphere microbiome structure under drought stress
Apr 6	Dr. Prathap Parameswaran	Associate Professor, Civil Engineering, Kansas State University	Circular bioeconomy for rural resiliency: Recovering efficient fertilizers, biogas, and water from diverse wastewaters with Anaerobic Membrane Bioreactors
Apr 13 *9am MST NAH 337	Dr. Mette Burmølle	Associate Professor, Microbiology, University of Copenhagen	Impact of interspecies interactions on structure and function of mixed biofilms
Apr 20	Scott Perl	Research Scientist, NASA, JPL	Preservation and validation of halophilic and psychrophilic microorganisms in Martian and icy moon analogs
Apr 27	Dr. Chelsea Heveran	Assistant Professor, Mechanical & Industrial Engineering, MSU, CBE	From bones to stones: Towards surmounting challenges in designing engineered living building materials
May 4	No Seminar – Last Week of Classes		
May 11	No Seminar – Finals Week		

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TECHNOLOGY TRANSFER:

Industrial Associates, 2022–23

Bold, new *Small business member

3M
Abradem Corp*
Arxada (formerly Lonza)
Baxter Healthcare
CardioQuip*
Church & Dwight Company
Decon7 Systems*
DeLaval
Earth Science Laboratories*
Ecolab
ICU Medical, Inc.
Kohler
Masco Corporation
Mölnlycke Health Care
NASA
Next Science
Olympus
Perfectus Biomed*
Procter & Gamble Company
Quest Medical
Redefining Clean*
Sharklet Technologies*
Smith & Nephew
Spinnaker International, LLC*
Sterilex*
STERIS
TerraStryke*
The Sherwin-Williams Company
Zimmer Biomet

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TECHNOLOGY TRANSFER:

Montana Biofilm Meeting
July 12–14, 2022

Monday
July 11

6:00–8:30 pm
Registration & Welcome Reception Larkspur Foyer

Tuesday
July 12

7:30–8:00 am
Registration & continental breakfast Larkspur Foyer

Meeting: Larkspur Ballroom

8:00-8:10
Opening Remarks
Matthew Fields, Director, CBE; Professor, Microbiology & Cell Biology, MSU
Paul Sturman, Industrial Coordinator, CBE

SESSION 1: Defining a Biofilm

8:10-8:15
Session Introduction
Darla Goeres, Research Professor of Regulatory Science, CBE

8:15-8:40
Biological films: Keeping the cart behind the horse
Matthew Fields

8:40-9:10
Industrial perspective on biofilm biology: Formation, maintenance, and mitigation
Chris Jones, Director, R&D, Sharklet Technologies

9:10-9:35
Important factors for defining medical biofilms
Garth James, PI, Medical Biofilms Laboratory, CBE; Associate Research Professor, Chemical & Biological Engineering, MSU

9:35-10:05 Break

10:05-10:30
The importance of clearly defining biofilm in laboratory standard test methods
Darla Goeres

10:30-11:00
Why evolution in biofilms is different, and some remarkable consequences
Vaughn Cooper, Professor, Microbiology & Molecular Genetics, Computational & Systems Biology, University of Pittsburgh

11:00-11:45
Panel Discussion
Vaughn Cooper
Matthew Fields
Garth James
Chris Jones
Moderator: Darla Goeres

11:45-12:00
Poster Pitches
CBE Researchers

12:00-1:00 Lunch

SESSION 2: CBE Imaging and Analysis Capabilities

1:00-1:20
Microscopy Core
Heidi Smith, Manager, Bio-Imaging Facility, CBE; Assistant Research Professor, Microbiol. & Cell Biology, MSU

1:20-1:40
CBE Analytical capabilities
Kristen Brileya, Technical Operations Manager, CBE

1:40-2:00
Statistical considerations in image analysis
Al Parker, Biostatistician, CBE; Associate Research Professor, Mathematical Sciences, MSU

2:00-2:15
MONT Highlight: Montana Microfabrication Facility (MMF) and the Imaging and Chemical Analysis Laboratory (ICAL)
Sara Zacher, Lab Manager, Imaging and Chemical Analysis Laboratory, MSU

2:15-2:40
Correlative microscopy links identity, morphology, biochemistry, and activity of uncultured microbes
Anthony Kohtz, PhD Student, Chemistry & Biochemistry, MSU, CBE

CBE Open House: Poster session and lab demonstrations

3:00–5:00
3rd Floor Barnard Hall, MSU
Schedule available onsite

Wednesday
July 13

7:30–8:00 am
Registration & continental breakfast Larkspur Foyer

Meeting: Larkspur Ballroom

SESSION 3: Medical Biofilms

8:00-8:10
Session Introduction
Garth James

8:10-8:40
Is there a universal biofilm defense?
Phil Stewart, Regents Professor, Chemical & Biological Engineering, MSU, CBE

8:40-9:10
Using organoid models to analyze gastrointestinal bacterial infections
Diane Bimczok, Associate Professor, Microbiology & Cell Biology, MSU, CBE

9:10-9:40
Biofilms and chronic wounds: An overview of recent Medical Biofilms Lab research
Elinor Pulcini, Assistant Research Professor, Chemical & Biological Eng., MSU, CBE

9:40-10:10 Break

10:10-10:40
Accumulation of protoporphyrin IX by biofilm bacteria attenuates bovine neutrophil responses
Joey Lockhart, Postdoctoral Researcher, Biological Sciences, University of Calgary *Young Investigator

10:40-11:10
Application of PNA-FISH based-methods for bacterial detection and localization in biofilms
Laura Cerqueira, Junior Researcher, Chemical Engineering, University of Porto *Young Investigator

Special Presentation

11:10-11:55
Functions of the *Pseudomonas aeruginosa* biofilm matrix proteins
Boo Shan Tseng, Assistant Professor, School of Life Sciences, University of Nevada Las Vegas

12:00-1:00 Lunch

SESSION 4: Engineered Biofilms

1:00-1:05
Session Introduction
Matthew Fields

1:05-1:35
From bones to sustainable building material
Chelsea Heveran, Assistant Professor, Mechanical & Industrial Eng., MSU, CBE

1:35-2:05
Untapped potential of fungal-based biofilms for water treatment and resource recovery
Erika Espinosa-Ortiz, Assistant Research Professor, Chemical & Biological Eng., CBE, MSU

2:05-2:35
Building synthetic biofilm with 3D hydrogel printing
Isaak Thornton, PhD Student, Mechanical & Industrial Engineering, MSU, CBE
Kathryn Zimlich, PhD Student, Microbiology & Cell Biology, MSU, CBE

2:35-3:05
Ureolytically-induced calcium carbonate composites as natural adhesives
Sobia Anjum, PhD Student, Chemical & Biological Eng., MSU, CBE

Strategic Planning Meeting for CBE Members

3:15-5:00
Hilton Garden Inn

6:00 BBQ Dinner
Big Yellow Barn, Bozeman

Thursday July 14

7:30–8:00 am
Registration & continental breakfast Larkspur Foyer

Meeting: Larkspur Ballroom

SESSION 5: Biofilms in Space

8:00-8:45
Session Introduction

Potential for biofouling control by nutrient removal in an ISS water system
Liz Sandvik, Research Engineer, CBE

8:45-9:15
Sensing slime: Microfabricated sensors to detect biofilm for space applications
Haley Ketteler, Masters Student, Electrical & Computer Eng., MSU, CBE
Matthew McGlennen, PhD Student, Mechanical & Industrial Eng., MSU, CBE

9:15-9:45
Off-planet production of high protein foods using fungal biomats
Ross Carlson, Professor, Chemical & Biological Eng., MSU, CBE

9:45-10:15 Break

10:15-10:45
Microbial isolation and characterization from two flex lines from the urine processor assembly onboard the International Space Station
Hang Nguyen, Microbiologist, JES Tech, NASA

10:45-11:15
Preliminary results of the ISS-operated *Pseudomonas aeruginosa* 'Space Biofilms' experiment
Pamela Flores, PhD Student, Molecular Cellular & Developmental Biology, University of Colorado, Boulder
Luis Zea, Assistant Research Professor, Aerospace Engineering Sciences, University of Colorado, Boulder

11:15 Meeting Wrap up

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WORKSHOP:

BIOFILM BASICS
July 11, 2022

9:00 – 9:30	**Welcome – *Matthew Fields, CBE Director*** **Group introductions** **Workshop Overview – *Paul Sturman***	**323 BH**
9:30 – 10:30	**Experimental Design for Biofilm Studies – *Al Parker*** **A Component Approach to Standard Methods – *Darla Goeres***	**323 BH**
10:30 – 10:45	***Morning Refreshments***	**323 BH**
10:45 – 11:45	**Biofilm Growth & Sampling Methods** ***Kelli Buckingham-Meyer & Diane Walker***	**323 BH**
11:45 - 12:00	**Workshop Group Photos Outside (weather permitting)**	
12:00 - 1:30	***LUNCH***	**Rendezvous Dining Hall**
1:30 – 2:45	**In the lab!** • **Reactor demos** • **Sampling biofilm**	**301 BH**
2:45 - 3:00	***Afternoon Refreshments***	**323 BH**
3:00 - 3:30	**Statistical Analysis of Standard Methods – *Al Parker***	**323 BH**
3:30 – 4:00	**Wrap-Up/Discussion**	**323 BH**

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TECHNOLOGY TRANSFER:

Anti-Biofilm Technologies: Pathways to Product Development Meeting
February 7–8, 2023

Tuesday
February 7

7:30–8:00
Registration & Coffee
Commonwealth Foyer
Meeting: Richmond/Roanoke

8:00–8:15
Opening Remarks
Matthew Fields
Director, CBE; Professor, Microbiology & Cell Biology, MSU
Paul Sturman, Industrial Coordinator, CBE

Keynote Presentation

8:15–9:00
OSEL Sterility and Infection Control Regulatory Science Program: A focus on stakeholder needs
Michael Eppihimer, Director, Division of Biology, Chemistry and Material Sciences, OSEL, CDRH, US FDA

SESSION 1: Reusable Medical Devices

9:00–9:30
Effect of protein concentration on biofilm formation in polytetrafluoroethylene tubing
Garth James, PI, Medical Biofilms Laboratory, CBE; Associate Research Professor, Chemical & Biological Engineering, MSU

9:30–10:00
Biofilm cleaning performance evaluation in Automated Endoscope Reprocessors
Bruno Haas, Group Leader, Scientific, Research and Validation Team, STERIS

10:00–10:30 Break

10:30–11:00
Current state of flexible endoscope reprocessing: Why is build-up biofilm a concern?
Michelle Alfa, President, AlfaMed Consulting, Ltd.

11:00–11:30
Analyzing biofilm reduction for cleaning of medical device surfaces
Katie Segars, Assistant Director, Division of Biology, Chemistry, and Materials Science, OSEL, CDRH, US FDA

Panel Discussion
11:30–12:30
Assessing cleaning and disinfecting procedures for reusable medical devices to improve patient safety
Michelle Alfa
Bruno Haas
Garth James
Katie Segars
Laura Wahlen, Baxter Healthcare
Moderator: Darla Goeres, CBE

12:30–1:30 Lunch Will/York

SESSION 2: Bioremediation

1:30–2:10
Session Introduction

In situ bioremediation of selenium and nitrate for full scale treatment of mine waste
Brent Peyton, Professor, Chemical & Biological Engineering, MSU, CBE

2:10–2:40
Pharmaceutical effects on a novel wastewater treatment biotechnology
Kylie Bodle, PhD Student, Civil Eng., MSU, CBE

2:40–3:10 Break

3:10–3:40
Bioremediation—State of Practice—A 'sampler' for biofilm devotees
Jim Cummings, Program Analyst, US EPA

3:40–4:10
Biofilm considerations: Bioremediation of contaminated groundwater
Birthe Veno Kjellerup, Associate Professor, Civil & Environmental Eng., University of Maryland

4:10–4:40
Expedited organo-halide destruction via biostimulation without augmentation supported by introduction of abiotic electron donor
Kent Armstrong, President, TerraStryke Products LLC

5:00–6:30 Networking Reception
Crystal Ballroom

Wednesday
February 8

7:45–8:20
Registration & Coffee
Commonwealth Foyer

SESSION 3: Emerging Surface Disinfection Methods

8:20–8:30
Session Introduction
Al Parker, Biostatistician, CBE; Associate Research Professor, Mathematical Sciences, MSU

8:30–9:00
An overview of EPA's guidance and methods for adding residual efficacy claims
Rebecca Pines, Branch Chief, Microbiology Laboratory Branch, Office of Pesticide Programs, US EPA

9:00–9:30
Multiple multi-lab evaluations of the Quantitative Method for determining the efficacy of antimicrobial substances against bacteria dried onto hard non-porous surfaces
Al Parker

9:30–10:00
Industry perspectives on the Quantitative Method to measure disinfection efficacy: Progress to improve reproducibility and parameters for assessing suitability as a regulatory standard
John Hilgren, Director, Regulatory Affairs, Ecolab

10:00–10:30 Break

10:30–11:00
Use of antimicrobial pesticides to address Legionella in cooling towers
Anastasia Swearingen, Senior Director, Chemical Products and Technology, American Chemistry Council

11:00–11:30
New method for Legionella pneumophila claims in cooling tower water
Lisa Smith, Team Leader, Microbiology Laboratory Branch, Office of Pesticide Programs, US EPA

11:30–12:00
Good riddance—The importance of biofilm removal and the need for standardized methods
Bruce Urtz, Microbiology Manager, Sterilex

12:00–1:00 Lunch Will/York

SESSION 4: Global Perspectives on Biofilm Claims

1:00-1:10
Session Introduction
Darla Goeres, Research Professor of Regulatory Science, CBE

1:10–1:40
Antibiofilm surfaces in the built environment: Current methods and considerations for method development
James Redfern, Senior Lecturer, Natural Sciences, Manchester Metro University

1:40–2:10
Prevention and treatment of biofilms–Update on European method development and claims
Florian Brill, Managing Director, Dr. Brill + Partner, GmbH

2:10–2:40
The UK's standpoint on biofilm claims and methods in the medical devices sector
Paulina Rakowska, Research and Innovation Development Manager, National Biofilms Innovation Centre (NBIC)

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TECHNOLOGY TRANSFER:

Industrial Interactions

Company	CBE Host	Interaction	Date
3M	Parker, Al	Presentation	July 26, 2022
Akagera Medicines	Parker, Al	CBE Visit	October 31, 2022
Arxada	Parker, Al	Consulting	October 7, 2022
Arxada	Parker, Al	Consulting	October 7, 2022
Arxada	Parker, Al	Consulting	March 27, 2023
Arxada	Parker, Al	Presentation	March 27, 2023
Arxada	Parker, Al	Webinar	April 17, 2023
AvantGuard	Parker, Al	CBE Visit, Consulting	March 29, 2023
AvantGuard	Sturman, Paul	CBE Visit	April 12, 2023
Baxter Healthcare Corp.	Parker, Al	Presentation	October 6, 2022
BioSure North America	Goeres, Darla	CBE Visit	June 21, 2023
BioSure North America	Kirker, Kelly	CBE Visit	June 21, 2023
BioSure North America	Fields, Matthew	CBE Visit	June 21, 2023
Church & Dwight Co.	James, Garth	Testing Project	March 27, 2023
Colgate-Palmolive	Goeres, Darla	Sponsored Project	November 3, 2022
Kersia	Stewart, Phil	Presentation	October 14, 2022
NASA	Goeres, Darla	Sponsored Project	February 23, 2023
Next Science	Parker, Al	Consulting	March 2, 2023
PSSI	Buckingham-Meyer, Kelli	CBE Visit	October 13, 2022
STERIS Corporation	Parker, Al	Consulting	September 14, 2022
STERIS Corporation	Parker, Al	Consulting	April 20, 2023

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OUTREACH:

Visiting Researchers

Name	Title	Home	CBE Host
Torie Prall	Teacher	Hawthorne Elementary School	Chelsea Heveran
Megan Brenna	Teacher	East Side Intermediate School	Chelsea Heveran
Lauren Arbaugh	Industry Researcher	BioSqueeze	Adie Philips and Al Cunningham
Sara Ortega	Postdoctoral Researcher	Delft University of Technology	Catherine Kirkland
Hunter Spitzer	Postdoctoral Researcher	University of North Carolina at Chapel Hill	Robin Gerlach
Kimberly King	Undergraduate Researcher		Ellen Lauchnor and Ranalda Tsosie
Lauren Crawford Bleazard	Undergraduate Researcher		Ellen Lauchnor and Ranalda Tsosie
Shuyi Lin	REU Student	Middlebury College	Chelsea Heveran
Ethan Dudley	REU Student	Berry College	Adie Phillips
Makda Fekade	REU Student	Brown University	Roland Hatzenpichler
Isabelle Johnson	REU Student	University of Montana	Brian Bothner
Noa Carlson	REU Student	Occidental College	Ross Carlson
Christopher Chengshi	REU Student	University of Pennsylvania	Robin Gerlach
Madyson Willis	REU Student	University of Wyoming	Garth James
Brynne Miller	REU Student	Brown University	Brian Bothner
Emma Buck	REU Student	Brown University	Ellen Lauchnor
Amelie Andreas	REU Student	Reed College	Christine Foreman
Ciara Pike	REU Student	Eastern Kentucky University	Valerie Copie
Nathan Bowman	REU Student	Georgia Institute of Technology	Matthew Fields

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OUTREACH:

Web image library use 2022-2023

Total image downloads: **64**

Requests for CBE graphics were submitted from **11** of the U.S. states:

California
Colorado
Illinois
Louisiana
Michigan
Montana
New Jersey
New York
Pennsylvania
Texas
Utah

There were requests from an additional **13** countries:

Argentina
Australia
Belgium
Canada
Chile
France
Germany
Japan
Mexico
Phillipines
Spain
The Netherlands
United Kingdom

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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; and 13 fully equipped research laboratories. See below for a comprehensive list of shared equipment available.

Bioimaging Core

The microscopy and chemical imaging facilities are coordinated by the Bioimaging Core 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 which are detailed below.

- **Leica Thunder widefield microscope** optimally configured for allow real-time, high-sensitivity, high-throughput imaging. This microscope is equipped with a cMOS Camera, a tunable multiline LED Light Source, an ultraprecise, triggerable stage, has complete Hardware Synchronization and is fully enclosed to maintain temperatures between ambient 5-50°C (± 0.1°C), humidity (specifically designed to prevent condensation), and CO_2/Air or hypoxic/hyperoxia conditions.

- **Leica DM6 upright fluorescent microscope** that is a fully automated with constant color temperature and fully automated transmitted light- and fluorescence axis, with motorized Z-focus.

- **A Nikon Eclipse E-800 research microscope** equipped with a Photometrics MYO cooled CCD camera and Universal Imaging Corporation's MetaVue software (v7.4.6)

- **Leica M 205 FA computer-controlled stereomicroscope** and Leica DFC3000G fluorescence camera

- **Nikon SMZ-1500-barrel zoom stereomicroscope** equipped with a color camera.

- **Leica CM1800 cryostat**

- **Dry ice maker**

- **Inverted Leica DMI8 Stellaris CSLM** with Digital Lights Sheet and Stimulated Raman Spectroscopy (SRS) capabilities This instrument enables lifetime and chemical imaging in real-time of intact biological samples under environmentally relevant conditions. This system is one of only three available at public universities and is equipped with a white light laser. The white light laser enables light gating to be applied to any excitation line from 460-660nm in combination with single photon imaging. This system is capable of lifetime imaging (FLIM-FRET). The digital light sheet module is ideal for sensitive 3D imaging of intact and complex samples. SRS uses two synchronized pulsed laser beams to coherently excite the selected molecular vibration of interest. SRS allows for extremely fast acquisition (103-106 faster than other classical Raman techniques) enabling close to real-time observation of cells. The inverted CSLM is also fully enclosed and contains an environmental control chamber to control temperature, humidity, CO2/Air or hypoxic/hyperoxia. Instrument is capable of high-resolution imaging (120nm of lateral resolution and 250nm of axial resolution).

- **Upright Leica DM6 Multiphoton CSLM**, equipped with a white light laser. This CSLM enables cutting-edge, real-time, high-sensitivity imaging of intact, complex biological samples. Like the inverted CSLM, this instrument is equipped with a white light laser enabling excitation within any line from 460-660nm in combination with single photon imaging. This system is capable of lifetime imaging (FLIM-FRET). The Multi-Photon Hyperspectral imaging (4-Tune) system on the upright CSLM will impact biofilm imaging by enabling increased penetration (>500 μm) and allow for label free imaging of mixed microbial samples. An Extended IR laser enables MP excitation from 680nm to 1300nm and MP imaging of red-shifted fluorophores (e.g., Alexa 568, 594). This upright CSLM is also fully enclosed and contains an environmental control chamber to control temperature and humidity.

- **ThorLabs Ganymede Series 200 Spectral Domain OCT** (Optical Coherence Tomography). OCT enables a stain-free, non-invasive, high resolution, real-time imaging of thick intact samples. This technique is well suited for imaging thick specimens. The OCT light source centered around 930 nm with a bandwidth >100 nm and has a scan rate of up to 36 kHz with an axial field of view of 2.9 mm / 2.2 mm. Depending on the scan objective the field of view (FOV) and resolution can be adjusted and vary between a larger FOV of 16x16 mm² at 12 µm resolution, and a FOV of 10x10 mm² with a higher resolution of 8µm.

- **Leica LMD6 Laser Microdissection Microscope**. The system enables the precise isolation of cells or specific regions of interest that can then be subjected to further downstream analysis (e.g., transcriptomics, isolation, and proteomics). This system is equipped with a color camera, fluorescence filter cubes (FITC, TRITC, DAPI), and a UV laser for sample dissection.

- **FlowCam 8100 Fluid Imager** is a flow imaging microscopy system that combines the benefits of digital imaging flow cytometry, and microcopy into a single platform. The system utilizes a color camera and digital imaging to image, size, and count passing particles in a liquid sample. Designed for aquatic research, the FlowCam 8100 can process 1mL samples in approximately 6 minutes to characterize suspended particles in a size range of 2µm to 1mm, surpassing the upper size limits of flow cytometry equipment on campus targeted to analyze single cells. The system has 2X, 4X, 10X, and 20X objectives and associated flow cells to assess single cells to larger particle sizes.

- **Modified Horiba Scientific LabRam HR Evolution NIR fully integrated high resolution Raman confocal microscope** equipped with optical tweezers and fast-mapping fluorescence capability with 450 mW 532 nm laser and a 100 mW 785 nm laser and ultra-low frequency filters for Stokes and anti-Stokes measurements.

- Two custom high-performance image analysis workstations are in the Center for Biofilm Engineering's Bioimaging Facility and are dedicated to image analysis and are equipped with state-of-the-art image analysis programs. All instruments are connected to 10 Gigabit networking for high-speed data transfer and coordinate with campus Research Computing (RCI) to offer large scale data storage and state of the art computational resources.

Analytical Core

- **Ion Chromatography**. Two ion chromatographs are available including a state-of-the-art **Dionex ICS-6000 HPIC** that can sequentially pull sample from one vial to analyze both cations and anions simultaneously using small sample volumes ~10 µL with two independent conductivity detectors. Alternately, the user can choose to analyze transition metals or lanthanides instead of cations with automated post column derivatization and a variable wavelength detector. For fast anion analysis without sample volume limitations, **the Dionex ICS 1100 anion IC** can be used to quantify most anions to parts per million levels with a conductivity detector.

- **Gas Chromatography**- Two gas chromatographs from SRI instruments are available for quantification of permanent gases by manual injection. The **SRI 8610C with thermal conductivity detecto**r is equipped for analysis of methane-producing cultures at 5-50% of atmospheric partial pressure. For lower detection limits **the SRI Multi-Gas 5 with TCD and FID methanizer** can quantify down to 0.1 ppm of CH4 on FID and 0.1 ppm and H2 on TCD with N2 carrier gas. Nitrogen fixation can also be monitored on this instrument via a traditional acetylene reduction assay, with quantification by GC of acetylene and ethylene in less than ten minutes per sample. The **Thermo Fisher Trace 1310 GC is equipped with a ISQ7000 mass spectrometer** for a detector and can be used for various analysis. Most commonly it is used with a DB23 column to quantify and identify Fatty Acid Methyl Esters (FAMES) produced by microalgae.

- **Liquid Chromatography.** Two highly modular liquid chromatographs are available**. The Dionex Ultimate 3000SD with VWD and RID** has a basic programmable autosampler, quaternary pump for complex gradients and two in-line detectors capable of quantifying most compounds that are excited by UV light (variable wavelength detector-UV) or that change the refractive index of the mobile phase (refractive index detector), encompassing organic acids, alcohols and sugars. For samples requiring a specific excitation and emission wavelength, the **Dionex Ultimate 3000RS with fluorescence detector** is tuneable and can detect across four different spectra simultaneously. The autosampler is programmable to accommodate needle derivatization methods such as OPA and FMOC pre-column derivatization of primary and secondary amines.

- **Total Carbon and Total Nitrogen.** Two carbon analyzers allow for measurements of non-purgeable organic carbon and dissolved inorganic carbon**. The Shimadzu TOC-L CPH** can also measure TN at the same time as NPOC. This high sensitivity instrument is reserved for analysis of pure samples with low TDS/salinity below 20 mg/L of C with a detection limit of 4 mg/L C making it ideal for drinking water and glacial ice analysis. For higher salt samples and 10 to 1000 mg/L C, **the Skalar LAS160** can perform technical replicates in about ten minutes per sample.

- **Spectrophotometry.** Two advanced plates readers from Biotek (now Agilent) can both perform analysis across the UV and visible spectrum in addition to bioluminescence assays. The **Synergy Hybrid H1MF MultiMode** reader has the full suite of capabilities including end point or kinetic scans and is compatible with the Take3 Plate for nucleic acid quantification. **The Synergy Neo2 MultiMode reader** is a faster, more sensitive plate reader that allows for incubation up to 65°C and can be used for high throughput screening with the addition of a plate stacker. Two basic UV-Vis spectrometers are available for other sample vessels. These **Genesys 10S UV-VIS scanning spectrophotometers** can accommodate cuvettes or test tubes.

Radioisotope Lab

- Liquid Scintillation Counter-Hidex 300SL

Microbiology/Media Preparation Lab

- Autoclave- Primus Gravity Eagle P ET21-104-00203
- Autoclave- Consolidated
- Autoclave- Consolidated 20x20x38 with nickel clad chamber SSR-3A-PB
- Micro Balance- Mettler Toledo MT5
- Dishwasher- Napco Floor Model NLW-200
- 2 Centrifuge- Sorvall Legend XTR CF8
- Water Purification System- Millipore Advantage A10
- Oven- Thermo Fisher Scientific 664
- ESPEC Benchtop Environmental Chamber
- 2 Shaking Incubators- VWR-Troemner, Ambient +5°C to 60°C
- Incubators at 30°C and 37°C

Molecular Biology Laboratory

- Nucleic acid sequencing can be performed using **the Illumina MiSeq sequencer**. 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).

- **Oxford Nanopore MinION** sequencing technology is transportable for use in the field or the lab where DNA and RNA can be sequenced directly, eliminating amplification bias and making it a valuable tool for studying modifications like methylation. It can be used for whole genome sequencing, targeted sequencing, RNA sequencing, metagenomics and epigenetics with read lengths determined by sample, from short to ultra-long reads (>4Mb).

- **QuantStudio 7 Pro Real-Time PCR system.** This advanced qPCR system is capable of multiplexing with 6 optical channels and 6 emission filters that are decoupled from excitation, allowing for 21 filter combinations for real time PCR analysis of complex samples. Excitation at 470, 520, 550, 580, 640 and 662 nm and emission at 520, 558, 586, 623, 682 and 711 nm. The 96 well block can hold plates or strip tubes for 0.1 mL volume and has 6 isolated zones with independent and precise temperature control capability. High sensitivity allows for detection of gene expression changes as small as 1.5-fold and a wide dynamic range of up to 10 log allows for tracking of broad changes in expression also.

- **PCR and gel analysis** equipment includes a gel documentation system with Point Grey Chameleon3 CM3-U3-31S4M Camera, two Eppendorf Mastercycler ep gradient thermocyclers and NanoDrop- Spectrophotometer ND1000 or Fluorospectrometer ND3300 for fast nucleic acid qualification. An Agilent Bioanalyzer 2100 is available for more in depth quantification and qualification of nucleic acid extractions for sequencing QA.

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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.

Medical Biofilm Laboratory

The Medical Biofilm Laboratory (MBL) has earned a reputation for being a university lab that focuses on industrially relevant medical research and testing as it relates to biofilms. Dr. Garth James (PhD, microbiology) and Dr. Kelly Kirker (PhD, bioengineering) are the leaders of this respected and adaptable lab group. The MBL team also includes two full-time research associates and two undergraduate research assistants. In addition to conducting research in support of NIH and DOD grants, the MBL has completed projects for over 100 companies. These projects have included the evaluation of antimicrobial wound dressings, wound washes and surgical lavages; the development of single-species and polymicrobial in-vitro biofilm models including biofilm/cell culture models; the characterization of biofilms from human and animal specimens; the evaluation of venous access catheters, needleless connectors, peritoneal dialysis catheters, urinary catheters, and catheter lock solutions; the evaluation of cochlear implants, neurostimulators, and other implanted medical devices; the testing of novel antibiofilm compounds and biomaterials; and the evaluation of root canal irrigants, mouthwashes, and toothpastes. The MBL is a prime example of integration at the CBE, bringing together applied biomedical science, biofilm microbiology, 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. Researchers in this lab have expertise in microbiology, molecular biology, biofilms, organic carbon characterization and instrument validation for life detection. They 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 CO_2, 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.

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.

OTHER Montana State University facilities available for collaborative research

Montana Nanotechnology (MONT) Facility

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

MSU Nuclear Magnetic Resonance (NMR) Facility

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

MSU Magnetic Resonance Microscopy (MRM) Facility

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

MSU ICAL Laboratory

The Image and Chemical Analysis Laboratory (ICAL) in the Physics Department at Montana State University is located on the 3rd floor of the EPS Building, adjacent to the Center for Biofilm Engineering. ICAL is a user-oriented facility that supports basic and applied research and education in all science and engineering disciplines at MSU. The laboratory provides access to state-of-the-art equipment, professional expertise, and individual training to government and academic institutions and the private sector. Laboratory instrumentation is dedicated to the characterization of materials through high resolution imaging and spectroscopy. ICAL promotes interdisciplinary collaboration between the research, educational and industrial fields, education, and industry, and to strengthen existing cooperation between the physical, biological, and engineering sciences by providing critically needed analytical facilities. These facilities are open to academic researchers.

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

The ICAL currently contains eleven complementary microanalytical systems:

- Atomic Force Microscope (AFM)
- Field Emission Scanning Electron Microscope (FE SEM)

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

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

CBE Computer Facilities

The CBE maintains several dedicated computational and data storage computer systems including 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. 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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