2024 APPENDIX

Center for Biofilm Engineering

Montana State University
Bozeman

Reporting Period:
June 1, 2023–May 31, 2024

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RESEARCH:

CBE RESEARCH AREAS

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

CBE RESEARCH:

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

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

APPLIED RESEARCH AREAS & PROJECTS

Biofilm control strategies antimicrobial efficacy | biocides | bioelectric effect | disinfectants | inhibitory coatings | bioactive compounds

Energy solutions biofuels | product souring | coal bed methane production | microbial fuel cells

Environmental technologies bioremediation | wetlands | CO_2 sequestration | biobarriers | biomineralization | microbes & mining issues

Health/medical biofilms chronic wound healing | catheter infections | oral health | food safety

Industrial systems & processes biofouling | biocorrosion | product contamination | microbe-metal interactions

Standardized methods product claims | regulatory issues | ASTM methods acceptance

Water systems drinking water quality | premise plumbing | water treatment | distribution systems

FUNDAMENTAL TOPICS

Biofilms in nature microbes in hot & cold environments | role of biofilms in natural processes | biomimetics | biogeochemistry

Cellular/intracellular phenotype | genetics | metabolic pathways | proteomics

Multicellular/extracellular flow and transport in biofilm systems | material properties | quorum sensing | structure-function | heterogeneities | matrix

Ecology/physiology population characterization | spatial and temporal population dynamics | anaerobic systems

ANALYTICAL TOOLS & TECHNIQUES

Instrumentation microscopy | nuclear magnetic resonance imaging | gas chromatography | microfluidics

Methods development experimental design | variability | ruggedness | repeatability | statistical evaluation

Modeling cellular automata modeling | mathematics | hydrodynamics | cohesive strength

Basic microbiology techniques total and direct counts | MIC determination | viable cell counts

Molecular biology techniques DNA extraction | PCR | DGGE | microarrays | sequencing

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RESEARCH:

2023–2024 CBE GRANT-FUNDED RESEARCH ACTIVITY

Current CBE Research Grants for Fiscal Year 2024 (July 1, 2023 to June 30, 2024)			
Research Area	Title	Principal Investigator	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	High-throughput droplet qRT-PCR microfluidic platform for quantification of virus from single cells	Loveday	Mayo Clinic
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	RAPID: Investigation of microbial:black carbon feedback processes that impact icefield melt in high latitude systems	Foreman	NSF
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	Real-time imaging of protein-protein interactions in bacterial biofilms	Smith	NIH
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
Energy Solutions	Nitrate Dependent Iron Oxidation	Peyton	SRK Consulting
Energy Solutions	NLC SRF Expert Advisory Meeting	Peyton	SRK Consulting
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
Medical Biofilms	Synergy between omics, symptoms, and healing trajectories of venous ulcers	Stewart	University of Florida
Medical Biofilms	Integrated Biofilm Control Strategies for Water Systems During Extended Space Flight	Stewart	NASA
Medical Biofilms	Mitigation and Prevention of Biofouling and Biofilm Growth in Wastewater Processing Assembly: Biocide and Nutrient Long Term Assessment	Stewart	NASA
Methods Development	Statistical Evaluation of Antimicrobial Test Methods and Related Data	Parker	EPA
Methods Development	Biofilm and Biomineralization Methods Development in Support of CRC 1313 Projects C04 and C05	Cunningham	Deutsche Forschungsgemeinschaft
Methods Development	Engineered Biological Cement for Surface Hardening in Semi-Aquatic Environments	Cunningham	Biosqueeze (DARPA)
Physiology & Ecology	RII Track-2 FEC: Data Driven Material Discovery Center for Bioengineering Innovation	Fields	South Dakota School of Mines
Physiology & Ecology	Environmental Networks Integrated with Genomes and Molecular Assemblies	Fields	Lawrence Berkley National Laboratory
Physiology & Ecology	Monitoring and managing microbial water quality for food safety	Fields	USDA
Biomechanics	FMSG: Biologically assembled and Recycled Construction and Structural materials (BRICS)	Heveran	NSF
Biomechanics	Developing Community in Engineered Living Materials	Heveran	NSF
Biomechanics	FMRG Eco: Manufacturing, repairing, and re-using biomineralized infrastructure materials through low-energy biological processes	Heveran	NSF
Geotechnical	MICP for Sustainable Infrastructure in Cold Regions	Khosravi	Wright Patterson Airforce Base
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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FY24 New CBE Research Grants (July 1, 2023 to June 30, 2024)

New CBE Research Grants Awarded in Fiscal Year 2024 (July 1, 2023 to June 30, 2024)				
Sponsor	**Title**	**PI**	**Period**	**Award Amount**
Deutsche Forschungsgemeinschaft	Biofilm and biomineralization methods development in support of CRC 1313 projects C0[4] and C0[5]*	Al Cunningham	1 Yr	$20,949
NSF	Developing Community in Engineered Living Materials	Chelsea Heveran	6 Mo	$39,794
NIH	Real-time imaging of protein-protein interactions in bacterial biofilms	Heidi Smith	1 Yr	$100,000
NASA	Mitigation and Prevention of Biofouling and Biofilm Growth in Wastewater Processing Assembly: Biocide and Nutrient Long Term Assessment	Phil Stewart	1 Yr	$170,000
USDA	Monitoring and managing microbial water quality for food safety	Matthew Fields	3 Yr	$900,000
NSF	FMRG Eco: Manufacturing, repairing, and re-using biomineralized infrastructure materials through low-energy biological processes	Chelsea Heveran	4 Yr	$2,989,176
BioSqueeze	Engineered Biological Cement for Surface Hardening in Semi-Aquatic Environments	Al Cunningham	1 Yr	$146,822
EPA	Statistical Evaluation of Antimicrobial Test Methods and Related Data	Al Parker	1 Yr	$139,630
Wright Patterson Air Force	MICP for Sustainable Infrastructure in Cold Regions	Mohammad Khosravi	1 Yr	$235,440
NSF	RAPID: Investigation of microbial: Black carbon feedback processes that impact icefield melt in high latitude systems.	Christine Foreman	1 Yr	$99,319
Deutsche Forschungsgemeinschaft	Biofilm and biomineralization methods development in support of CRC 1313 projects C0[4] and C0[5]*	Al Cunningham	1 Yr	$20,949
NSF	Developing Community in Engineered Living Materials	Chelsea Heveran	6 Mo	$39,794
NIH	Real-time imaging of protein-protein interactions in bacterial biofilms	Heidi Smith	1 Yr	$100,000
NASA	Mitigation and Prevention of Biofouling and Biofilm Growth in Wastewater Processing Assembly: Biocide and Nutrient Long Term Assessment	Phil Stewart	1 Yr	$170,000
	Total Grant Awards to CBE in Fiscal Year 2024			**$4,841,130**
	**Additional funding awarded to existing grants in FY24 (budget increased by the amount listed)*			

FY 2024 New Award Credit to CBE on next page

New Research Grants with Credit Given to CBE FY2024						
Sponsor	**Title**	**PI**	**Period**	**Award Amount**	**Credit %**	**Award to CBE**
NIH	Single cell heterogeneity of influenza A virus genetic diversity and host adaptation using drop-based microfluidics	Emma Loveday	2 Yr	$234,019	50%	$117,010
Massachusetts Institute of Technology	Multi-functional, survivable ELMs grown from programmable fungal-bacteria consortia	Ross Carlson	3 Yr	$930,000	33%	$306,900
USDA	Pure maple yeast for pure maple distillates	Seth Walk	3 Yr	$255,954	100%	$255,954
NSF	REU Site: Participant Support Exploring the Limits of Life - Understanding Biofilms in Extreme Environments	Brent Peyton	3 Yr	$390,542	100%	$390,542
NSF	REU Site:(non-PS) Exploring the Limits of Life: Biofilms in Extreme Environments	Brent Peyton	3 Yr	$86,798	100%	$86,798
Total Grant Credit Awarded to CBE in Fiscal Year 2024						**$1,157,204**

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RESEARCH:
PUBLICATIONS
June 2023–June 2024

2023 Publications

Sanchez, Humberto, **Connie B. Chang**, "Open-source pneumatic pressure pump for drop-based microfluidic flow controls," *Eng Res Exp.*, 5(3):035014. 23-015.

McGlennen, Matthew, **Markus Dieser**, **Christine M. Foreman**, **Stephan Warnat**, "Monitoring biofilm growth and dispersal in real-time with impedance biosensors" *J Indust Microbiol Biotechnol*, 2023, 50:kuad022. 23-016.

Owkes, Mark, Kai Coblentz, Austen Eriksson, Takumi Kammerzell, **Philip S. Stewart**, "Biofilm.jl: A fast solver for one-dimensional biofilm chemistry and ecology," Computer Physics Communications, 2023, 293:108890. 23-017.

Ausbacher, D., **Lindsey A. Miller, Darla M. Goeres**, **Philip S. Stewart**, M.B. Strøm, A. Fallarero, "α,α-disubstituted β-amino amides eliminate *Staphylococcus aureus* biofilms by membrane disruption and biomass removal," *Biofilm*, 2023, *6*: 100151. 23-018.

Stewart, Philip S., M. Owkes, "Simulation of catalase-dependent tolerance of microbial biofilm to hydrogen peroxide with a biofilm computer model," *Biofilms Microbiomes*, 2023, 9:60. 23-019.

Bodle, Kylie B., Rebecca C. Mueller, **Madeline R. Pernat**, **Catherine M. Kirkland**, "Treatment performance and microbial community structure in an aerobic granular sludge sequencing batch reactor amended with diclofenac, erythromycin, and gemfibrozil," *Front Microbiomes*, 2023, 2:1242895. 23-020.

Fredrikson, Jacob P., Priyanka P. Brahmachary, Ronald K. June, Lewis M. Cox, **Connie B. Chang**, "Pericellular matrix formation and atomic force microscopy of single primary human chondrocytes cultured in alginate microgels," *Adv Biol*, 2023, 2300268. 23-021.

Kaiser-Jackson^, Lauren B., Markus Dieser, Matthew McGlennen, Albert E. Parker, Christine M. Foreman, Stephan Warnat, "Detection of microbes in ice using microfabricated impedance spectroscopy sensors, *ECS Sensors Plus*, 2023 2:042801. 23-022.

Hashimi, M., T.A. Sebrell, Jodi F. Hedges, Deann Snyder, Katrina N. Lyon, Stephanie D. Byrum, Samuel G. Mackintosh, Dan Crowley, Michelle D. Cherne, David Skwarchuk, Amanda Robison, **Barkan Sidar**, Anja Kunze, **Emma K. Loveday**, Matthew P. Taylor, **Connie B. Chang**, **James N. Wilking**, Seth T. Walk, Tony Schountz, Mark A. Jutila, **Diane Bimczok**, "Antiviral responses in a Jamaican fruit bat intestinal organoid model of SARS-CoV-2 infection," *Nat Comms*, 2023 14:6882. 23-023.

Parker, Albert E., J.W. Arbogast, "Sample sizes for estimating the sensitivity of a monitoring system that generates repeated binary outcomes with autocorrelation," *Stat Meth Med Res*, 2023, 32(12):2347-2364. 23-024.

Foreman, Christine M., **Heidi J. Smith**, **Markus Dieser**, "Seven genome sequences of bacterial, environmental isolates from Pony Lake, Antarctica," *Microbiol Res Announc*, 2023: e00744-23. 23-025.

Heveran, Chelsea M., Christopher J. Hernandez, "Make engineered living materials carry their weight," *Matter*, 2023, 6(11): 3705-3718. 23-026.

Starrett, W. Grant, Arbogast, James W., **Albert E. Parker**, Pamela T. Wagner, Susan E. Mahrer, Vanessa Christian, Barbara L. Lane, V. Lorraine Cheek, Gregory Robins, John M. Boyce, Hari Polenakovik, "The effect of a prospective intervention program with automated monitoring of hand hygiene performance in long-term and acute-care units at a Veterans Affairs medical center," *Infection Cont Hosp Epidemiol*, 2023, 1–8. 23-027.

Murali, Ranjani, Hang Yu, Daan R. Speth, Fabai Wu, Kyle S. Metacalfe, Antoine Crémière, Rafael Laso-Pèrez, Rex R. Malmstrom, Danielle Goudeau, Tanja Woyke, **Roland Hatzenpichler,** Grayson L. Chadwick, Stephanie A. Connon, Victoria J. Orphan, "Physiological potential and evolutionary trajectories of syntrophic sulfate-reducing bacterial partners of anaerobic methanotrophic archaea," *PLOS Biol*, 2023, 21(9): e3002292. 23-028.

Goeres, Darla M., Yo-Ann Velez-Justiniano, Birthe Veno Kjellerup, Robert JC. McLean, "Biofilm and human spaceflight," *Biofilm*, 6:100150. 23-029.

Ugur, Gizem U., **Kylee Rux**, John Connor Boone, **Rachel Seaman**, Recep Avci, **Robin Gerlach**, **Adrienne Phillips**, **Chelsea Heveran**, "Biotrapping ureolytic bacteria on sand to improve the efficiency of biocementation," *ACS Appl Mat Interf* 16(2):2075-2085. 23-030.

Smith, Heidi J., Michael J. Franklin, "Chapter 10 - Use of epifluorescence widefield deconvolution microscopy for imaging and three-dimensional rendering of *Pseudomonas aeruginosa* biofilms and extracellular matrix materials," *Meth Microbiol*, 2023, 53: 309-324. 23-031.

Espinosa-Ortiz, Erika J., **Robin Gerlach**, **Brent M. Peyton**, **Luke Roberson**, "Biofilm reactors for the treatment of used water in space: potential, challenges, and future perspectives," *Biofilm*, 2023, 6:100140. 23-032.

Haas±, Bruno, Sarah James±, **Albert E. Parker**, **Marie-Claude Gagnon±**, Noémie Goulet, Philippe Labrie, "Comparison of quantification methods for an endoscope lumen biofilm model," *Biofilm,* 2023, 6:100163. 23-033.

Regulski, Matthew, **Matthew F. Myntti±**, **Garth A. James**, "Anti-Biofilm Efficacy of Commonly Used Wound Care Products in In Vitro Settings," *Antibiotics*, 12(3):536. 23-034.

2024 Publications

Bodle, Kylie B., **Catherine M. Kirkland**, "Pharmaceutical impacts on aerobic granular sludge morphology and potential implications for abiotic removal," *Chemosphere*, 2024, 350:141187. 24-001.

Devine, Connor C., **Kenna C. Brown**, Kat O. Paton, **Chelsea M. Heveran**, Stephen A. Martin, "Rapamycin does not alter bone microarchitecture or material properties quality in young-adult and aged female C57BL/6 mice," *JBMR Plus*, 2024, 8(2): ziae001. 24-002.

Miller, Lindsey A., Kelli Buckingham-Meyer, Darla M. Goeres, "Simulated aging of draught beer line tubing increases biofilm contamination," *Intl J Food Microbiol*, 2024, 415:110630. 24-003.

Fern, J., A.J.Cunliffe, **Darla M. Goeres**, **Nuno F. Azevedo**, J. Verran, "Critical analysis of methods to determine growth, control and analysis of biofilms for potential non-submerged antibiofilm surfaces and coatings," *Biofilm*, 2024, 7:10087. 24-004.

Fredrikson^, Jacob P., Luke F. Domanico, **Shawna L. Pratt**, **Emma K. Loveday**, Matthew P. Taylor, **Connie B. Chang**, "Single-cell herpes simplex virus type 1 infection of neurons using drop-based microfluidics reveals heterogeneous replication kinetics," *Sci Adv.*, 2024, 10(9):eadk9185. 24-005.

Teska^, Christy J., **Markus Dieser**, **Christine M. Foreman**, "Clothing textiles as carriers of biological ice nucleation active particles," *Environ Sci Technol*, 2024, 58(14):6305-6312. 24-006.

Barnhart, Elliott P., Stacy M. Kinsey, Peter R. Wright, Sara L. Caldwell, Vince Hill, Amy Kahler, Mia Mattioli, Robert S. Cornman, Deborah Iwanowicz, Zachary Eddy, Sandra Halonen, **Rebecca Mueller**, **Brent M. Peyton**, Geoffrey J. Puzon, "*Naegleria fowleri* detected in Grand Teton National Park Hot Springs," *ACS EST Water,* 2024, 4(2):628-637. 24-007.

Goemann, Hannah M., **Danielle E.M. Ulrich**, **Brent M. Peyton**, La Verne Gallegos-Graves, **Rebecca C. Mueller**, "Severe and mild drought cause distinct phylogenetically linked shifts in the blue grama (*Bouteloua gracilis*) rhizobiome," *Front Microbiomes*, 2024, 2:frmbi.2023.1310790. 24-008.

Malinowski, Natalia, Matthew J. Morgan, Jason Wylie, Tom Walsh, Sergio Domingos, Suzanne Metcalfe, Anna H. Kaksonen, **Elliott P. Barnhart**, **Rebecca Mueller**, Brent M. Peyton, Geoffrey J. Puzon, "Prokaryotic microbial ecology as an ecosurveillance tool for eukaryotic pathogen colonisation: Meiothermus and Naegleria fowleri," *Water Research*, 254:121426. 24-009.

Saraçoğlu, Mert, Mubashir Mansoor, Utku Bakırdöven, **Handenur Arpalı**, Utku Orçun Gezici, Servet Timur, "Challenging the frontiers of superparamagnetism through strain engineering: DFT investigation and co-precipitation synthesis of large aggregated Fe3O4 (magnetite) powder," *J Alloys Comp*, 968:171895. 24-010.

Olds, Sabine, Hudson Dorian, Adrienne Phillips, Mohammed Khosravi, Catherine Kirkland, Alfred Cunningham, Lauren Arbaugh, **Randy Hiebert**, "Bio-cementation via microbially induced calcium carbonate precipitation for surface applications: The effects of sand particle size on uniformity and strength," *Geo-Congress* 2024:186-195. 24-011.

Welhaven^, Hope D., Ethan Viles, Jenna Starke, Cameron Wallace, Brian Bothner, Ronald K. June, Alyssa K. Hahn, "Metabolomic profiles of cartilage and bone reflect tissue type, radiography-confirmed osteoarthritis, and spatial location within the joint," *Biochem Biophys Res Comm*, 703: 149683. 24-012.

Mackenzie M. Lynes, **Zackary J. Jay**, **Anthony J. Kohtz**, **Roland Hatzenpichler**, Methylotrophic methanogenesis in the *Archaeoglobi* revealed by cultivation of *Ca. Methanoglobus hypatiae* from a Yellowstone hot spring, *ISME J*, 2024, 18(1): wrae026. 24-013.

Barbosa, Ana, Nuno F. Azevedo, **Darla M. Goeres**, Laura Cerqueira, "Ecology of *Legionella pneumophila* biofilms: The link between transcriptional activity and the biphasic cycle," *Biofilm*, June 2024, 7:100196. 24-014.

Ayotte, Stephanie H., Christopher R. Allen, **Albert Parker**, **Otto R. Stein**, **Ellen G. Lauchnor**, "Greenhouse gas production from an intermittently dosed cold-climate wastewater treatment wetland," *Sci Tot Environ*, May 2024, 924:171484. 24-015.

Gunyol, Pinar, Mohammad Khosravi, **Adrienne Phillips**, Kathryn Plymesser, **Albert Parker**, "Effect of fines content on calcium carbonate precipitation and thermal properties of biocemented sand," *J Geotech Geoenviron Eng*, July 2024, 150(7): 04024047. 24-016.

Wood, Jason M., Camilla Urbaniak, Ceth Parker, Nitin Kumar Singh, Season Wong, Arunkumar Arumugan, **Dana J. Skorupa**, **Ashlyn Hemmah**, Phoebe Laaguiby, Fathi Karouia, **Brent M. Peyton**, Scott Tighe, Kasthuri Venkateswaran, "Assessing microbial diversity in Yellowstone National Park hot springs using a field deployable automated nucleic acid extraction system,"

Front Ecol Evol, February 2024, 12:fevo.2024.1306008.
24-017.

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

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RESEARCH:
PRESENTATIONS
June 2023–June 2024

Abigail Greenberg, Undergraduate Student "Needleless connectors experiment: Summer 2023" Undergraduate Student Research Celebration, 4/25/2024, Bozeman, MT, Poster.

Adrienne Arnold, Graduate Student "Metabolic modeling of salinity tolerance in a green microalgae" MCB-RIP presentations, 11/17/2023, Bozeman, MT, Invited talk.

Al Parker, Faculty
"Statistical considerations when using presence/absence assays in microbiology" Applied Math Seminar, MSU, 2/8/2024, Bozeman, MT, Invited talk.

"After the biofilm: bacterial transfer, infections and hand hygiene," Montana American Statistical Association Meeting, 9/29/2023, Bozeman, MT, Invited talk.

Amit Acharjee, Graduate Student "Effects of surface roughness on Microbiologically Influenced Corrosion (MIC) of copper 101 by *Oleidesulfovibrio alaskensis* G20" Montana Biofilm Meeting, 7/12/2023, Bozeman, MT, Invited talk.

B. Tegner Jacobson, Graduate Student "The respiratory pathogen *Mycoplasma ovipneumoniae* forms biofilms that increase resistance to antibiotic treatment" Conference for Research Workers in Animal Disease, 1/20/2024, Chicago, IL, Invited talk.

Coleman Lewis, Undergraduate Student "Biofilm.jl graphical user interface" Undergraduate Student Research Celebration, 4/25/2024, Bozeman, MT, Poster.

Eli Selong, Graduate Student "Alternative approach for antibiotic susceptibility determination in Mycoplasma biofilms" Conference for Research Workers in Animal Disease, 1/20/2024, Chicago, IL, Invited talk.

Elizabeth Sandvik, Faculty "A biocide study for microbial control in the International Space Station Wastewater Recovery System" Montana Biofilm Meeting, 7/11/2023, Bozeman, MT, Invited talk.

Garth James, Faculty "Bacterial ingress through valves used for venous access" Montana Biofilm Meeting, 7/12/2023, Bozeman, MT, Invited talk.

Haley Ketteler, Graduate Student "An overview of spacecraft water recycling systems and biofouling concerns" Pretty Porous Science Lecture, University of Stuttgart, 6/6/2024, Virtual, Invited talk.

Hannah Goemann, Graduate Student
"Increasing drought severity elicits a gradient response in the plant physiology, root exudation, and rhizosphere community composition of blue grama grass," Ecological Society of America Annual Meeting, 8/9/2023, Portland, OR, Invited talk.

"16S Ratios method for analysis of active microbial communities" Montana Biofilm Meeting, 7/11/2023, Bozeman, MT, Invited talk.

Heidi Smith, Faculty "Imaging for biofilm characterization" Montana Biofilm Meeting, 7/11/2023, Bozeman, MT, Invited talk.

Iwona Beech, Faculty "The relevance investigating microbiome, metabolome, and microstructure to understanding of microbially influences corrosion in oilfield installations" LABS10, 11/19/2023, Virtual, Invited talk.

Jake Marquis, Graduate Student "Microfluidic platforms for the simulation of bacterial transport through a contaminated aquifer," Pretty Porous Science Lecture, University of Stuttgart, 6/6/2024, Virtual, Invited talk.

Jennifer Crandall Graduate Student "Detecting in situ microbial activity in coastal oxygen minimum zone across methane and nitrite gradients" Research In Progress, 4/12/2024, Bozeman, MT, Invited talk.

JP Kaffer, Graduate Student "Importance of algal culture history for sustainable fuel and chemical production" MCB-RIP presentations, 4/26/2024, Bozeman, MT, Invited talk.

Katerina Bruhl, Undergraduate Student "Metabolic profiling of *Rhodanobacter sp. R12* and *Acidovorax sp. 3H11* with preferred carbon/nitrogen sources: Implications for optimized denitrification in synthetic microbial communities" Undergraduate Student Research Celebration, 4/25/2024, Bozeman, MT, Poster.

Katrina Lyon, Graduate Student "Human organoid models for gastric mucus layer physiology" MCB-RIP presentations, 11/17/2023, Bozeman, MT, Invited talk.

Levi Bala, Undergraduate Student "Incorporating gels in microbially induced calcite precipitation to decrease time in shale core sealing" Undergraduate Student Research Celebration, 4/25/2024, Bozeman, MT, Poster.

Lexia Dauenhauer, Undergraduate Student "Aging alters the subchondral bone response 7 days after non-invasive traumatic joint injury in C57BL/6JN mice" Undergraduate Student Research Celebration, 4/25/2024, Bozeman, MT, Poster.

Madelyn Mettler, Graduate Student "Mixed domain biofilm responses to coated surfaces" Montana Biofilm Meeting, 7/12/2023, Bozeman, MT, Invited talk.

Madison Basile, Undergraduate Student "Kinetics of denitrification by *Pseudomonas stutzeri* and *Dechloromonas denitrificans*" Undergraduate Student Research Celebration, 4/25/2024, Bozeman, MT, Poster.

Michael Neubauer, Graduate Student Measuring mechanical properties of chondrocyte cells using microfluidics, Pretty Porous Science Lecture, University of Stuttgart, 6/6/2024, Virtual, Invited talk.

Otto Stein, Faculty "Optimizing denitrification in a cold weather two-stage vertical flow treatment wetland using operational controls" 10th Wetland Pollutant Dynamics and Control International Symposium, 9/10/2023, Bruges, Belgium, Oral presentation.

Phil Stewart, Faculty "Hydrogen peroxide vs biofilms" Montana Biofilm Meeting, 7/12/2023, Bozeman, MT, Invited talk.

Robin Gerlach, Faculty "Biotechnology, biomineralization and biofilms in porous media," InterPore Academy Webinar, 6/25/2024, Virtual, Invited Talk.

Ross Carlson, Faculty "Food fights and conflict avoidance: A systems biology analysis of contrarian Pseudomonas aeruginosa substrate preferences," Montana Biofilm Meeting, 7/11/2023, Bozeman, MT, Invited talk.

Sabine Olds, Graduate Student "Ammonium by-product management via zeolite adsorption and struvite precipitation" Pretty Porous Science Lecture, University of Stuttgart, 6/6/2024, Virtual, Invited talk.
Sophia Adams, Undergraduate Student "Molecular differences between water and land fowl cell lines when exposed to avian influenza" Undergraduate Student Research Celebration, 4/25/2024, Bozeman, MT, Poster.

Stephan Warnat, Faculty
"Micro-sensor technology" Montana Biofilm Meeting, 7/11/2023, Bozeman, MT, Invited talk.
"Micro-Sensor Technology for Biofilm Detection" Pretty Porous Science Lecture, University of Stuttgart, 6/6/2024, Virtual, Invited talk.

Stephanie Ayotte, Graduate Student, 10th Wetland Pollutant Dynamics and Control International Symposium, 9/10/2023, Bruges, Belgium, Oral presentations
"Microbial community dynamics in a cold-climate treatment wetland"

"Greenhouse gas emissions from a cold-climate treatment wetland"

Tess Kirkpatrick, Undergraduate Student, "Growth of *Cutibacterium acnes* and *Staphylococcus epidermidis* in a defined, skin-relevant medium" Undergraduate Student Research Celebration, 4/25/2024, Bozeman, MT, Poster.

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RESEARCH:

CBE Affiliated Faculty and Their Specialties, 2023–2024

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	Environmental microbiology and biotechnology
Dana Skorupa	Chemical & Biological Engineering	Microbes in extreme environments
Darla Goeres	Chemical & Biological Engineering	Standardized biofilm methods
Diane Bimczok	Microbiology & Immunology	Mucosal immunology
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 & Immunology	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, biofilm transport phenomena, gels and colloids
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 & Immunology	Environmental biofilms
Michael Franklin	Microbiology & Immunology	Molecular genetics, gene expression, alginate biosynthesis; *Pseudomonas*
Otto Stein	Civil Engineering	Engineered waste remediation
Frank Stewart	Microbiology & Immunology	Aquatic microbiology; symbiosis; genomics
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 & Immunology	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 2023, Fall 2023, Spring 2024

*****Graduating ‡Native American

1.	Adams, Sophia Kouko (Loveday)	F	Chemistry & Biochemistry	Maple Valley, WA
2.	Albrecht, Emma (Fields)	F	Microbiology & Cell Biology	Stillwater, MN
3.	Auth, Avery (Lauchnor)	F	Civil Engineering	Spokane, WA
4.	Awram, Kalena (Peyton)	F	Chemical & Biological Engineering	N. Vancouver, Canada
5.	Baker, Tate (Stewart)	F	Biomedical Engineering	North Bend, WA
6.	*Bala, Levi (Phillips/Kirkland)	M	Civil Engineering	Heber City, UT
7.	Basile, Madison (Lauchnor/Stein)	F	Civil Engineering	Missoula, MT
8.	Bayse, Lauren (Carlson)	F	Civil Engineering	Gilbert, AZ
9.	Bomber, Allyson (Phillips)	F	Civil Engineering	Corvallis, OR
10.	Boyles, Genesis (Gerlach)	F	Civil Engineering	McAllister, MT
11.	*Buckner, Elizabeth (Goeres)	F	Microbiology & Cell Biology	Kalispell, MT
12.	Butler, Cara (Kirkland)	F	Civil Engineering	Fort Collins, CO
13.	*Bruhl, Katerina (Fields)	F	Microbiology & Cell Biology	Maple Valley, WA
14.	Caldwell, Kate (Loveday)	F	Chemistry & Biochemistry	San Antonio, TX
15.	Carey, Taylor (Peyton)	F	Chemical & Biological Engineering	Wasilla, AK
16.	Castro, Allison (Peyton)	F	Microbiology & Cell Biology	Erie, CO
17.	Dauenhauer, Lexia (Heveran)	F	Chemical & Biological Engineering	Butte, MT
18.	Delker, Katherine (Stewart)	F	Microbiology & Cell Biology	Soldotna, AK
19.	DeMarco, Jamie (Chang)	F	Chemical & Biological Engineering	Billings, MT
20.	Diehl, Lydia (Peyton)	F	Ecology	Bozeman, MT
21.	Evans, Emily (Espinosa-Ortiz/Gerlach)	F	Microbiology & Cell Biology	Fort Shaw, MT
22.	Faber, Jessica (Kirkland)	F	Civil Engineering	Parker, CO
23.	Feltman, Maren (Lauchnor)	F	Chemical & Biological Engineering	Ketchum, ID
24.	Ferguson-Reiner, Emma (Fields)	F	Chemical & Biological Engineering	Kalispell, MT
25.	*****Greenberg, Abigail (Huth/James)	F	Microbiology & Cell Biology	Billings, MT
26.	Grimshaw, Aaron (Lauchnor)	M	Civil Engineering	Kalispell, MT
27.	Gray, Chase (Hatzenpichler)	M	Chemistry & Biochemistry	Havre, MT
28.	Haab, Amanda (Fields)	F	Microbiology & Cell Biology	Helena, MT
29.	Hannigan, Cora Rose (Phillips)	F	Civil Engineering	Lake Stevens, WA
30.	*Harms, Kaelyn (Phillips)	F	Civil Engineering	Eagle, ID
31.	*Heyneman, Ethan (Heveran)	M	Chemical & Biological Engineering	Fishtail, MT
32.	*Hickethier, Micah (Stewart)	F	Chemical & Biological Engineering	Kalispell, MT
33.	Hoogerheide, Dylan (Lauchnor)	M	Chemical & Biological Engineering	Helena, MT
34.	Hyatt, William (Phillips)	M	Civil Engineering	Whitefish, MT
35.	Jackson, Ruby (Warnat/Foreman)	F	Mechanical & Industrial Engineering	Kalama, WA
36.	Johnson, Anna (Gerlach)	F	Chemical & Biological Engineering	Cranberry Township, PA
37.	Karaman, Imre (K. Connolly/H. Smith)	F	Chemical & Biological Engineering	Istanbul, Turkey
38.	*****Keim, Emelia (James)	F	Microbiology & Cell Biology	Moscow, ID
39.	*Kirkpatrick, Tess (Fields)	F	Chemistry & Biochemistry	Corrales, NM
40.	Knutson, Keigan (Stewart)	M	Microbiology & Cell Biology	Kalispell, MT
41.	Krysiak, Nicole (Foreman)	F	Chemistry & Biochemistry	Arvada, CO
42.	LeBrun, Kathrine (Heveran)	F	Chemical & Biological Engineering	Laurel, MT
43.	Lewis, Coleman (Stewart)	M	Electrical & Computer Engineering	Denver, CO
44.	Lord, Alexa (Phillips)	F	Civil Engineering	Lakewood, CO
45.	May, Andrew (Peyton)	M	Chemical & Biological Engineering	Castle Pines, CO
46.	McAneney, Sean (Lauchnor)	M	Civil Engineering	
47.	Myxter, Alexander (Peyton)	M	Land Resources and Environmental Sciences	Fort Collins, CO
48.	Novak, Abby (Fields)	F	Plant Sciences & Plant Pathology	Wasilla, AK
49.	Rahn, Jessica (Phillips)	F	Civil Engineering	Pawnee, CA
50.	Renner, Konrad (James)	M	Microbiology & Cell Biology	Eagle River, AK
51.	Ritter, Kadin (Warnat)	M	Mechanical & Industrial Engineering	Golden, CO
52.	Robles, Grayson (James)	M	Microbiology & Cell Biology	Highlands Ranch, CO
53.	Roemig, Grace (Heveran)	F	Mechanical & Industrial Engineering	Excelsior, MN

54.	Schultz, Marika (Phillips)	F	Civil Engineering	Bozeman, MT
55.	Skibicki, Sylvie (Heveran)	F	Art	Bozeman, MT
56.	Solsberg, Rylee (Lauchnor)	F	Civil Engineering	Bozeman, MT
57.	Trudnowski, Anna (Heveran)	F	Mechanical & Industrial Engineering	Butte, MT
58.	Ward, Maya (Connolly)	F	Chemical & Biological Engineering	Missoula, MT
59.	Watson, Steven (Heveran)	M	Chemical & Biological Engineering	Barrington, NH
60.	Yatso, Marcella (Kirkland)	F	Civil Engineering	Shorewood, WI

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Undergraduates Summary: 2023–2024

Department	Male	Female	Total
Art		1F	1
Biomedical Engineering		1F	1
Chemical & Biological Engineering	4M	11F	15
Chemistry & Biochemistry	2M	4F	6
Civil Engineering	4M	14F	18
Ecology		1F	1
Electrical & Computer Engineering	1M		1
Land Resources and Environmental Sciences	1M		1
Mechanical & Industrial Engineering	1M	3F	4
Microbiology & Cell Biology	2M	9F	11
Plant Sciences & Plant Pathology		1F	1
Totals	**15M**	**45F**	**60**

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EDUCATION:

Graduate Students: Summer 2023, Fall 2023, Spring 2024

‡ Native American *Received degree

Masters Candidates

1.	Arpali, Handenur (Warnat/Foreman)	F	Chemical & Biological Engineering	Istanbul, Turkey
2.	Bayliss, Bennet (Loveday)	M	Chemical & Biological Engineering	Montrose, CO
3.	*Bedey, Kayla (Phillips/Kirkland)	F	Civil Engineering	Madisonville, LA
4.	*Brush, Kristen (Stein)	F	Civil Engineering	Delray Beach, FL
5.	Culp, Matthew (Warnat)	M	Mechanical & Industrial Engineering	Maple Valley, WA
6.	*Delwiche, Jenna (Phillips/Lauchnor)	F	Civil Engineering	Portland, OR
7.	*Dorian, Hudson (Phillips/Khosravi)	M	Civil Engineering	Fresno, CA
8.	*Keskin, Yagmur (Peyton/Fields)	F	Chemical & Biological Engineering	Tire, Turkey
9.	Kessler, Kendall (Carlson)	F	Chemical & Biological Engineering	Kalispell, MT
10.	Ketteler, Haley (Foreman/Warnat)	F	Electrical & Computer Engineering	Pierre, SD
11.	Lyon, Katrina (Wilking)	F	Microbiology & Cell Biology	Highwood, IL
12.	Nichols, Winifred (Fields)	F	Land Resources & Environmental Sci.	Bozeman, MT
13.	Palen, Thomas (Warnat)	M	Mechanical & Industrial Engineering	Kenne, NY
14.	Vallie, James (Peyton)	M	Chemical & Biological Engineering	Crow Agency, MT
15.	*Ugur, Elif (Heveran/Phillips)	F	Mechanical & Industrial Engineering	Sinop, Turkey

PhD Candidates

1.	Acharjee, Amit (Amendola/Fields)	M	Mechanical & Industrial Engineering	Dhaka, Bangladesh
2.	Alonge, Babatunde (Ryan)	M	Chemistry & Biochemistry	Lagos, Nigeria
3.	Andreas, Elizabeth (Carlson)	F	Mathematical Sciences	Evanston, WY
4.	*Anjum, Sobia (Gerlach)	F	Civil Engineering	Punjab, Pakistan
5.	Arnold, Adrienne (Carlson)	F	Microbiology & Cell Biology	Charleston, WV
6.	Ayotte, Stephanie (Lauchnor/Stein)	F	Civil Engineering	Saco, ME
7.	Aviles Zuniga, Tadeo (Loveday)	M	Computer Science	Burbank, CA
8.	*Bodle, Kylie (Kirkland)	F	Civil Engineering	Camano Island, WA
9.	Boles, Bruce (Foreman)	M	Chemical & Biological Engineering	Knoxville, TN
10.	Brown, Kenna (Heveran)	X	Mechanical & Industrial Engineering	Grand Junction, CO
11.	Carrano, Isabella (Fields)	F	Microbiology & Cell Biology	Livermore, CA
12.	*Casey, Cailin (Heveran)	F	Mechanical & Industrial Engineering	Concord, NH
13.	Christian, William (Hatzenpichler)	M	Chemistry & Biochemistry	Grand Rapids, MT
14.	Crandall, Jennifer (Fields/Hatzenpichler)	F	Microbiology & Immunology	Wallingford, CT
15.	Darrow, Cheyenne (Foreman)	F	Microbiology & Cell Biology	Hemet, CA
16.	Demeritte, Amethyst (Stewart/Livinghouse)	F	Chemistry & Biochemistry	New Providence, Bahamas
17.	Davidson, Leah (Heveran)	F	Mechanical & Industrial Engineering	Boise, ID
18.	Du, Martina (Carlson)	F	Chemical & Biological Engineering	Kent, WA
19.	Garner, Madeline (Foreman)	F	Molecular Biosciences	Cookeville, TN
20.	Gattiker, Jasper (Bimczok)	M	Microbiology & Cell Biology	Watkinsville, GA
21.	Gaur, Gauri (Stewart)	F	Microbiology & Cell Biology	Gurgaon, India
22.	Griffin, Gabriel (Gerlach)	M	Chemical & Biological Engineering	Hancock, MI
23.	*Goemann, Calvin (Gerlach)	M	Microbiology & Cell Biology	Isanti, MN
24.	*Goemann, Hannah (Peyton)	F	Microbiology & Cell Biology	Wells, MN
25.	Hoffman, Carter (Chang)	M	Chemical & Biological Engineering	Carlsbad, CA
26.	Holcomb, Charles (Gerlach)	M	Chemical & Biological Engineering	Great Falls, MT
27.	Joshi, Pukar (Phillips)	M	Civil Engineering	Morang, Nepal
28.	Kaffer, John (Peyton)	M	Microbiology & Cell Biology	Madison, AL
29.	Khadivar, Hossein (Gerlach)	M	Civil Engineering	San Marcos, CA
30.	*Kohtz, Anthony (Hatzenpichler)	M	Chemistry & Biochemistry	Omaha, NE
31.	*Koenig, Heidi (Stewart/Livinghouse)	F	Chemistry & Biochemistry	Effie, MB
32.	Koepnick, Hannah (Peyton)	F	Chemical & Biological Engineering	Sherman, TX

33.	Kugbajor, El-Freda (Amendola)	F	Mechanical & Industrial Engineering	Kumasi, Gana
34.	Marquis, James (Fields)	M	Microbiology & Cell Biology	Mill Valley, CA
35.	McLean, Anthony (Hatzenpichler)	M	Microbiology and Cell Biology	Bozeman, MT
36.	Mettler, Madelyn (Peyton)	F	Chemical & Biological Engineering	Littleton, CO
37.	Mikesell, Logan (Stewart)	M	Chemistry & Biochemistry	Onsted, MI
38.	*Miller, Isaac (Fields)	M	Microbiology & Cell Biology	Helena, MT
39.	Mozaffari, Arash (Stein/Lauchnor)	M	Civil Engineering	Qazin, Iran
40.	Neubauer, Michael (Warnat)	M	Mechanical & Industrial Engineering	Rogers, MN
41.	Nupp, Sylvia (Hatzenpichler)	F	Chemistry & Biochemistry	Russellville, AK
42.	Opp, Breuklyn (Gerlach)	F	Chemical & Biological Engineering	Charles City, IA
43.	Putnam, Campbell (Carlson)	M	Chemical & Biological Engineering	Hattiesburg, MS
44.	*Schaible, George (Hatzenpichler)	M	Chemistry & Biochemistry	Missoula, MT
45.	Schimetz, Jacob (Hatzenpichler)	M	Microbiology & Cell Biology	Plymouth, MN
46.	Shikany, Johnathan (Peyton)	M	Chemical & Biological Engineering	Bellingham, WA
47.	Shreve, Molly (Fields)	F	Microbiology & Cell Biology	Louisville, KY
48.	Stanley-Thompson, Maribelle (Wilking)	F	Chemical & Biological Engineering	Corvallis, OR
49.	Strupulis, Chloe (Bimczok/Wilking)	F	Chemical & Biological Engineering	Anchorage, AK
50.	Thomas, Mallory (Chang)	F	Microbiology & Cell Biology	Elkhart, IN
51.	Thornton, Isaak (Wilking)	M	Mechanical & Industrial Engineering	Great Falls, MT
52.	Willett, Matthew (Kirkland)	M	Chemical & Biological Engineering	Puyallup, WA
53.	Willis, Madelyne (Foreman)	F	Land Resources & Environmental Sciences	Atlanta, GA
54.	Wood, Jessica (Fields)	F	Microbiology & Cell Biology	Lafayette, IN
55.	*Vahidi, Ghazal (Heveran)	F	Mechanical & Industrial Engineering	Gorgan, Iran
56.	Viles, Ethan (Heveran)	M	Mechanical & Industrial Engineering	Veradale, WA
57.	Zimlich, Kathryn (Fields)	F	Microbiology & Cell Biology	Dublin, OH

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EDUCATION:
Graduate Students, 2023–2024

18: Chemical & Biological Engineering

MS: 5

2 M Bayliss, Bennet: MS, *Loveday*
Vallie, James: MS, *Peyton*

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

PhD: 13

7 M Boles, Bruce: PhD, *Foreman*
Griffin, Gabriel: PhD, *Espinosa-Ortiz/Gerlach*
Hoffman, Carter: PhD, *Chang*
Holcomb, Charles: PhD, *Gerlach*
Putnam, Campbell: PhD, *Carlson*
Shikany, Jonathan: PhD, *Peyton*
Willett, Matthew: PhD, *Kirkland*

5 F Du, Martina: PhD, *Carlson*
Koepnick, Hannah: PhD, P*eyton*
Mettler, Madelyn: PhD, P*eyton*
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

5 M Alonge, Babatunde: PhD, *Ryan*
Christian, William: PhD, *Hatzenpichler*
Kohtz, Anthony: PhD, *Hatzenpichler*
Mikesell, Logan: PhD, *Stewart/Livinghouse*
Schaible, George: PhD, *Hatzenpichler*

3 F Demeritte, Amethyst: PhD, *Stewart/Livinghouse*
Koenig, Heidi, PhD, *Stewart/Livinghouse*
Nupp, Sylvia: PhD, *Hatzenpichler*

11: Civil Engineering

MS: 4

1 M Dorian, Hudson: MS, *Phillips/Khosravi*

3 F Bedey, Kayla: MS, *Phillips*
Brush, Kristen: MS, *Stein*
Delwiche, Jenna: MS, *Phillips/Lauchnor*

PhD: 6

3 M Joshi, Pukar: PhD, *Phillips*
Khadivar, Hossein: PhD, *Gerlach*
Mozaffari, Mohammed: PhD, S*tein/Lauchnor*

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

1: Electrical & Computer Engineering

MS: 1

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

2: Land Resources & Environmental Sciences

MS: 1

1 F Nichols, Winifred: MS, *Fields*

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 Culp, Matthew: MS, *Warnat*
Palen, Thomas: MS, *Warnat*

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

PhD: 9

4 M Acharjee, Amit: PhD, *Amendola/Fields*
Neubauer, Michael: MS, *Warnat*
Thornton, Isaak: PhD, *Wilking*
Viles, Ethan: PhD, *Heveran/Gerlach*

4 F Casey, Cailin: PhD, *Heveran*
Davidson, Leah: PhD, *Heveran*
Kugbajor, El-Freda: PhD, *Amendol*a
Vahidi, Ghazal: PhD, *Heveran*

1 X Brown, Kenna: PhD, *Heveran*

18: Microbiology & Cell Biology

MS: 1

1 F Lyon, Katrina: MS, Bimczok/*Wilking*

PhD: 17

7 M
Gattiker, Jasper: PhD, *Bimczok*
Goemann, Calvin: PhD, *Gerlach*
Kaffer, John: PhD, *Peyton*
Marquis, James: PhD, *Fields*
McLean, Anthony: PhD, *Hatzenpichler*
Miller, Isaac: PhD, *Fields*
Schimetz, Jacob: PhD, *Hatzenpichler*

10 F
Arnold, Adrienne: PhD, *Carlson*
Carrano, Isabella: PhD, *Fields*
Crandall, Jennifer: PhD, *Hatzenpichler/Fields*
Darrow, Cheyenne: PhD, *Foreman*
Gaur, Gauri: PhD, *Stewart*
Goemann, Hannah: PhD, *Peyton*
Shreve, Molly: PhD, *Fields*
Thomas, Mallory: PhD, *Chang*
Wood, Jessica: PhD, *Fields*
Zimlich, Kathryn: PhD, *Fields*

1: Molecular Biosciences

PhD: 1

1 F
Garner, Madeline: PhD, *Foreman*

TOTALS –

Total Grads: 72

Total MS: 15	5 M / 10 F
Total PhD: 57	28 M / 27 F / 2 X

Total Male: 33
Total Female: 37
Total Non-Binary: 2

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EDUCATION:

Graduating with advanced degrees: June 2023–June 2024

Kristen Brush MS, Chemistry & Biochemistry, July 2023
Influence of dose volume on nitrogen removal in a two-stage vertical flow treatment wetland: Bridger Bowl Ski Area case study

Dorian Hudson MS, Mechanical & Industrial Engineering, July 2023
Feasibility study for field-scale use of ureolysis-induced calcite precipitation (UICP) for roadbed improvement

Mackenzie Lynes PhD, Chemistry & Biochemistry, July 2023
Distribution, diversity, and physiology of uncultured MCR-encoding microbial populations in Yellowstone Hot Springs

Humberto Sanchez PhD, Chemical & Biological Engineering, July 2023
Development and optimization of drop-based microfluidic devices and periphery equipment

Kayla Bedey MS, Civil Engineering, November 2023
Comparing the mechanical properties of shale cores: Intact vs fractured and sealed with UICP

Hannah Goemann PhD, Microbiology & Cell Biology, November 2023
Rhizobiome dynamics in plant growth promotion and abiotic stress response

Yagmur Keskin MS Chemical & Biological Engineering, November 2023
Biocorrosion of copper *Oleidesulfovibrio alaskensis* G20 biofilms in static and dynamic environments

Isaac Miller PhD, Microbiology & Cell Biology, November 2023
Phycosomal dynamics in xenic cultures of the alkali tolerant green microalga *Chlorella sp. SLA-04*

Elif Ugur MS, Chemical & Biological Engineering, November 2023
Bio-trapping ureolytic bacteria on sand to improve the efficiency of biocementation

George Schaible PhD, Chemistry & Biochemistry, January 2024
Investigating organized complexity in multicellular magnetotactic bacteria using culture independent techniques

Kylie Bodle, PhD, Chemical & Biological Engineering, April 2024
Assessing a novel approach to pharmaceutical removal from wastewater: Aerobic granular sludge

Cailin Casey PhD, Mechanical & Industrial Engineering, April 2024
Multi-length scale mechanical investigation of the flying insect thorax

Heidi Koenig PhD, Chemistry & Biochemistry, April 2024
Synthesis and biological evaluation of novel antimicrobial agents for the control and eradication of pathogenic biofilms

Ghazal Vahidi PhD, Mechanical & Industrial Engineering, April 2024
Determining the impact of osteocyte lacunar-canalicular turnover on bone matrix quality

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EDUCATION:

Center for Biofilm Engineering

Seminar Series: Fall 2023

Thursdays, 2:10 p.m. MDT
BARNARD 108, Montana State University

Date	Speaker	Affiliation	Presentation Title
10/5	Dr. Jin Yan	Assistant Professor of Molecular, Cellular & Developmental Biology, Yale University	Bacterial biofilm as self-shaping active matter
10/12	Dr. Laura Jennings	Research Assistant Professor, Biological Sciences, University of Montana	Sugar-coated, multidrug-resistant bacteria as targets for new antimicrobial therapeutics
10/19	Dr. Sunanda Sharma	Postdoctoral Scholar, Jet Propulsion Laboratory	Searching for organics and minerals on Mars with SHERLOC
10/26	Dr. Hannah Schweitzer	ORISE Research Scientist, DOE-NETL; Affiliate Research Faculty, Montana State University	Diversity and selection of surface marine microbiomes in Arctic ecosystems
11/2	Dr. Andrew Jones	Assistant Professor, Civil and Environmental Engineering, Duke University	Defending the Colony: Mathematical and experimental tools for studying Pseudomonas aeruginosa
11/9	Dr. Sheyda Azimi	Assistant Professor, Biology, Georgia State University	Intra-species bacterial population dynamics shapes the biogeography of infection
11/16	Dr. Julia Willett	Assistant Professor, Microbiology and Immunology, University of Minnesota	Functional genomics of Enterococcus faecalis biofilm formation and morphology
11/23	No Seminar - Fall Break		
12/7	No Seminar - Last week of classes		

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EDUCATION:

Center for Biofilm Engineering

Seminar Series: Spring 2024

Thursdays, 2:10 p.m. MDT
BARNARD 108, Montana State University

Date	Speaker	Affiliation	Presentation Title
01/25	No Seminar		
02/08	Dr. Phil Stewart	Regents Professor, Chemical & Biological Engineering, Montana State University, Center for Biofilm Engineering	Laboratory testing of antimicrobial activity and innate immune system compatibility
03/14	No Seminar – Spring Break		
03/21 CBE Undergraduate Research Day	Sophia Adams	Montana State University, Center for Biofilm Engineering, Advisor: Emma Loveday	Chickens, ducks, and how they get sick: An exploration of avian influenza using drop-based microfluidics
	Nikki Krysiak	Montana State University, Center for Biofilm Engineering, Advisor: Christine Foreman	Determining if microorganisms could survive in ocean world environments
	Eli Selong	Montana State University, Chemistry & Biochemistry, Advisor: Emma Loveday	Alternative approach for antibiotic susceptibility determination in Mycoplasma biofilms
04/04 *Alt time: 9:00 AM MDT *Alt location: NAH 337	Dr. Katharine Coyte	University of Manchester	How does horizontal gene transfer shape microbial communities?
04/11	Dr. Catherine Armbruster	Assistant Professor, Biological Sciences, Carnegie Mellon University	Potable water biofilms as a reservoir of opportunistic pathogens that cause cystic fibrosis respiratory infections
04/25	Dr. Chris Lemon	Assistant Professor, Chemistry and Biochemistry, Montana State University	Repurposing heme proteins for bioimaging and biosensing
05/02	No Seminar – Last week of classes		

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TECHNOLOGY TRANSFER:

Industrial Associates, 2023–24

Bold, new *Small business member

3M (Solventum, April 1, 2024)
Arxada
Avant Guard LLC*
Baxter Healthcare
BioSure North America*
CardioQuip*
Church & Dwight Company
Decon7 Systems*
DeLaval
ICU Medical, Inc.
Johnson & Johnson
Masco Corporation
Mölnlycke Health Care
NASA
Newell Brands
Next Science
Olympus
PerfectCLEAN*
Perfectus Biomed*
PhaseOne Health*
Procter & Gamble Company
ProEdge Dental*
Quest Medical
Redefining Clean*
Sanuwave Health*
Sharklet Technologies*
Sterilex*
STERIS
The Sherwin-Williams Company
Zimmer Biomet

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TECHNOLOGY TRANSFER:

Montana Biofilm Meeting
July 11-13, 2023

Monday
July 10

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

Tuesday
July 11

7:00-8:00 am CBE & IA Members Coffee Talk Boardroom

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 Darla Goeres, Industrial Coordinator, CBE

SESSION 1: Multispecies Biofilms

8:10-8:15
Session Introduction
Chris Jones, PI, Standardized Biofilm Methods Laboratory, CBE

8:15-8:45
War and Peace: Polymicrobial interactions during cystic fibrosis airway disease
Dominique Limoli, Assistant Professor, Microbiology & Immunology, University of Iowa

8:45-9:15
A biocide study for microbial control in the International Space Station Wastewater Recovery System
Liz Sandvik, Research Engineer, CBE

9:15-9:45
Using a fluorescent probe staining method and COMSAT to assess cell viability in *Aspergillus niger* biofilms treated with antimicrobial agents
Aswathy Shailaja, Postdoctoral Associate, Pediatrics, Duke University Medical Center
Young Investigator Award

9:45-10:15
Food fights and conflict avoidance: A systems biology analysis of contrarian *Pseudomonas aeruginosa* substrate preferences
Ross Carlson, Professor, Chemical & Biological Engineering, MSU, CBE

10:15-10:45 Break

10:45-11:45
Panel: Challenges & rewards of using a multispecies biofilm in the lab
Ross Carlson
Dominique Limoli
Liz Sandvik
Aswathy Shailaja
Moderator: Chris Jones

11:45-12:00
Lightning presentations
CBE Student Researchers

12:00-1:00 Lunch

SESSION 2: Measuring Biofilm

1:00-1:30
Session Introduction
Micro-sensor technology
Stephan Warnat, Assistant Professor, Mechanical & Industrial Eng., MSU, CBE

1:30-1:55
Imaging for biofilm characterization
Heidi Smith, Manager, Bioimaging Facility, CBE; Asst. Research Professor, Microbiology & Cell Biology, MSU

1:55-2:20
Investigating microbial biofilms as indicators of heavy metals in the Clark Fork Basin, Montana
Elliott Barnhart, Research Hydrologist, USGS

2:20-2:45
16S Ratios method for analysis of active microbial communities
Hannah Goemann, PhD student, Microbiology & Cell Biology, MSU, CBE

2:45
Transport to CBE laboratories

CBE Open House: Poster session and lab demonstrations

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

Wednesday
July 12

7:00-8:00 am CBE & IA Members Coffee Talk Boardroom

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

Meeting: Larkspur Ballroom

8:00-8:05
Opening remarks
Matthew Fields, Darla Goeres

SESSION 3: Medical Biofilms &The Hospital Environment

8:05-8:15
Session Introduction
Kelly Kirker, Assistant Research Professor, Chemical & Biological Eng., MSU, CBE

8:15-8:45
Hydrogen peroxide vs biofilms
Phil Stewart, Regents Professor, Chemical & Biological Engineering, MSU, CBE

8:45-9:15
Bacterial ingress through valves used for venous access
Garth James, PI, Medical Biofilms Laboratory, CBE; Associate Research Professor, Chemical & Biological Engineering, MSU

9:15-9:45
Electrochemical bandage
Haluk Beyenal, Professor, The Gene and Linda Voiland School of Chemical Engineering and Bioengineering, Washington State University

9:45-10:15 Break

10:15-10:45
Metabolic niche composition affects bacteriophage replication in adherent-invasive *Escherichia coli* biofilms
Robert Brzozowski, Postdoctoral Researcher, Biological Sciences, University of Montana
Young Investigator Award

State of the CBE
10:45-11:30
Matthew Fields

11:30-1:00 Lunch

SESSION 4: Biofilm & Surfaces Interactions

1:00-1:10
Session Introduction
Madelyn Mettler, PhD Student, Chemical & Biological Engineering, MSU, CBE

Keynote Presentation
1:10-1:55
What's a surface?: Surface sensing in *Pseudomonas aeruginosa*
Matthew Parsek, Professor, Microbiology, University of Washington

1:55-2:30
Effects of surface roughness on Microbiologically Influenced Corrosion (MIC) of copper 101 by *Oleidesulfovibrio alaskensis* G20
Amit Acharjee, PhD Student, Materials Science, MSU, CBE

2:30-3:00
Mixed domain biofilm responses to coated surfaces
Madelyn Mettler

3:00-3:30 Break

Strategic Planning Meeting for CBE Members
3:30-5:00
Hilton Garden Inn

BBQ Dinner
6:00
Big Yellow Barn, Bozeman

Thursday July 13

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

Meeting: Larkspur Ballroom

SESSION 5: Engineered Living Materials

8:00-8:30
Session Introduction
Matthew Fields
Chelsea Heveran, Assistant Professor, Mechanical & Industrial Eng., MSU, CBE

8:30-9:00
Programming bacteria to grow into macroscopic, tailored materials
Marimikel Charrier, Senior Research Specialist, Biosciences, Rice University

9:00-9:30
Engineered Living Building Materials: From concept to commercialization
Wil Srubar, Associate Professor, Civil & Architectural Eng., University of Colorado

9:30-10:15
Industry Panel

10:15-10:45 Break

10:45-11:15
3D printing of engineered bacteria for the production of biofilms-on-a-chip
Anne Meyer, Associate Professor, Biology, Univ. of Rochester

11:15-11:45
Polymer platforms for 3D printing engineered living materials
Alshakim Nelson, Professor, Chemistry, Univ. of Washington

11:45-12:15
Biologically fabricated materials from engineered microbes
Neel Joshi, Associate Professor, Chemistry & Chemical Biology, Northeastern University

12:15-1:15 Lunch

1:15-2:00
Small Group Discussion

2:00-2:45
Moderated Whole Group Discussion

2:45-3:15 Break

3:15-4:00
Government Agency Panel

4:00-4:45
Moderated Whole Group Discussion, Part 2

4:45-5:00
Closing Remarks

6:30
Networking Social, Bogert Park

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TECHNOLOGY TRANSFER:
Anti-biofilm Technologies: Pathways to Product Development Meeting
Jan. 31–Feb. 1, 2024

Wednesday January 31

7:30–8:00
Continental Breakfast
Studio B Prefunction Area

Meeting: Studio B

8:00–8:10
Introductory Remarks
Matthew Fields
Director, CBE; Professor, Microbiology & Cell Biology, MSU
Darla Goeres, Industrial Coordinator, Regulatory Research Professor, CBE

Keynote Presentation

8:10–8:55
Antimicrobial-containing wound care devices: Navigating the regulatory landscape
Brandon Kitchel, Microbiologist/Expert Reviewer, Office of Surgical and Infection Control Devices, US FDA

SESSION 1: Wounds & NTM Lung Infections

8:55-9:00
Session Introduction
Kelly Kirker, Assistant Research Professor, Chemical & Biological Engineering, MSU, CBE

9:00–9:30
Microbiome of venous leg ulcers
Garth James, PI, Medical Biofilms Laboratory, CBE; Assoc. Research Professor, Chemical & Biological Engineering, MSU

9:30–10:00
Clinical studies interrogating the prevention and treatment of surgical site infections and chronic wounds
Sybil D'Costa, Senior Manager, Clinical Operations, Next Science

10:00–10:30
Laboratory testing of antimicrobial activity and innate immune system compatibility
Phil Stewart, Regents Professor, Chemical & Biological Engineering, MSU, CBE

10:30–11:00 Break

11:00–11:30
Flying under the radar: Mycobacterium abscesses—a stealthy pathogen?
Luanne Hall Stoodley, Associate Professor, Microbial Infection & Immunity, College of Medicine, The Ohio State University

11:30–12:00
Aerosolized bacteria: From world-wide infections to addressing regulatory science needs
Jon Weeks, Acting Assistant Director, Sterility & Infection Control Program, CDRH, US FDA

12:00–12:15
Session Summary
Kelly Kirker

12:15–1:30 Lunch Studio D

SESSION 2: Self-Regulating Industries

1:30-1:35
Session Introduction
Darla Goeres

1:35–2:05
What's the deal with the ADA Seal?
Prerna Gopal, Senior Manager, Seal and Standards, American Dental Association

2:05–2:35
Viscoelasticity as a therapeutic target to remove dental biofilms
Erin Gloag, Assistant Professor, Microbiology, Virginia Polytechnic Univ.

2:35–3:05
How cross sector collaboration helped define benchmarks used for OTC antimicrobial mouth rinses
Michael Lynch, Director, Fellow, Global Scientific Engagement, Oral Health, Kenvue

3:05–3:35 Break

3:35–4:05
Pathways for personal care product registration: Cosmetic vs. over-the-counter drug vs. new drug approval
Jim Arbogast, President, JW Arbogast Advanced Science Consulting LLC

4:05–4:35
Session Summary
Darla Goeres

4:35–6:00 Networking Reception Studio D

Thursday February 1

8:00–8:30
Continental Breakfast
Studio B Prefunction Area

Meeting: Studio B

SESSION 3: Hard Surface Disinfection

8:30–8:35
Introductory Remarks
Darla Goeres

8:35–8:40
Session Introduction
Chris Jones, PI, Standardized Biofilm Methods Lab, CBE

8:40–9:10
Quantitative efficacy assessment of antimicrobials against bacteria, spores, viruses, and fungi
Rebecca Pines, Branch Chief, Microbiology Laboratory Branch, Office of Pesticide Programs, US EPA

9:10–9:40
Statistical considerations of presence/absence assays in microbiology
Al Parker, Biostatistician, CBE; Associate Research Professor, Mathematical Sciences, MSU

9:40–10:10
The need, or not, for a standardized test method for biofilm kill claims in food production
Bruce Urtz, Microbiology Manager, Sterilex

Continued on next page

10:10–10:40 Break

10:40–11:10
Polymeric n-Halamines for antimicrobial surfaces
Marc Hein, Chief Technology Officer, AvantGuard

11:10–11:40
New ASTM Quantitative Towelette Method
Ryan Karcher, Biologist, Microbiology Laboratory Branch, Office of Pesticide Programs, US EPA
Lisa Smith, Team Leader, Microbiology Laboratory Branch, Office of Pesticide Programs, US EPA

11:40–11:55
Session Summary
Chris Jones

11:55–12:00
Closing Remarks
Darla Goeres

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OUTREACH:

Visiting Researchers

Name	Title	Home University	CBE Host
Gigi Montague	Undergraduate Researcher	Middlebury College	Chelsea Heveran
Giorgia Ghiara	Fulbright Scholar	Torino, Italy	Roberta Amendola
Melinda Barath	REU Student	St. Lawrence University	Phil Stewart
Sophie Courtney	REU Student	University of Pennsylvania	Emma Loveday
Mitchell Gray	REU Student	Western New England University	Stephan Warnat
Alicia Guerrero-Gobert	REU Student	Blackfeet Community College	Robin Gerlach
Juliana Guerrero-Gobert	REU Student	Blackfeet Community College	Ellen Lauchnor
Kaylanna Guerrero-Gobert	REU Student	Blackfeet Community College	Robin Gerlach
Ellen Henry	REU Student	Lehigh University	Adie Phillips
Zachary Leopold	REU Student	University of Alabama - Tuscaloosa	Christine Foreman
Diliya Murtazina	REU Student	University of Tennessee	Matthew Fields
Rachel Seaman	REU Student	St. Lawrence University	Robin Gerlach
Sarah Shick	REU Student	Arizona State University	Emma Loveday
Justus Smith	REU Student	Auburn University	Matthew Fields
Zoey Teal	REU Student	Vermont State University at Castleton	Danielle Ulrich
Lauren Yumibe	REU Student	Washington University in St. Louis	Ellen Lauchnor

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OUTREACH:

Web image library use 2023-2024

Total image downloads: **83**

Requests for CBE graphics were submitted from **15** of the U.S. states:

Colorado	Michigan	New York
Florida	Minnesota	North Carolina
Georgia	Montana	Ohio
Illinois	Nevada	Texas
Indiana	New Jersey	Virginia

There were requests from an additional **12** countries:

Canada	Japan	Sweden
France	Mexico	The Netherlands
Germany	Russia	Ukraine
India	Spain	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 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 mL 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 in 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

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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.

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.

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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.

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