
2021 APPENDIX

Center for Biofilm
Engineering

Montana State
University Bozeman

Reporting Period:
June 1, 2020–May 31, 2021

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RESEARCH:

CBE RESEARCH AREAS

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

CBE RESEARCH:

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

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

APPLIED RESEARCH AREAS & PROJECTS

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

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

Environmental technologies bioremediation | wetlands | CO₂ sequestration | 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

RESEARCH:

2020–2021 CBE GRANT-FUNDED RESEARCH ACTIVITY

Current CBE Research Grants for Fiscal Year 2021 (July 1, 2020 to June 30, 2021)			
Research Area	Title	Principal Investigator	Funding Agency
Biofilm Mechanics	Exploring Biofilm Material Properties with Micromechanical Tools	Wilking	NSF
Biofilm Mechanics	Collaborative Research: Modeling Gastric Mucus Layer Physiology with Application to Helicobacter Pylori and Gastric Organoids	Wilking	UTAUNI
Biofilm Mechanics	3D-Printing of Microbial Communities for Optimal Resource Processing	Wilking	ARREOF
Biofilm Mechanics	Freedom chip: High-speed, low cost, high-throughput viral-load detector	Wilking	Ult Safety
Biofilm Mechanics	VIPER: Viral Interdiction through Population Engineering and Restructuring	Chang	NCSU
Biofilm Mechanics	CAREER: Understanding Spatial Heterogeneity in Biofilms Using Colloidal Engineering	Chang	NSF
Biofilm Mechanics	LAMP: Expanding Screening Capacity to Enhance Montana's COVID-19 Response Capabilities	Chang	Office of Commissioner of Higher Ed
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	Chang	NIH
Biofilm Mechanics	Sanchez supplement; Integration of mononuclear phagocytes - GOFLOWChip	Chang	NIH
Biofilms in Nature	SLICE: Spectral Signs of Life in Ice	Foreman	NASA
Biofilms in Nature	Eradication of Microbial Contamination in Metal Working Fluids	Foreman	NSF
Biofilms in Nature	Spatial Excitation Emission Matrix Spectroscopy instrument (SEEMS)	Foreman	Impossible Sensing
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
Energy Solutions	Screening for biofilm production in ISS microorganisms using CDC bioreactor	Peyton	Jet Propulsion Lab
Energy Solutions	Nitrate Dependent Iron Oxidation	Peyton	SRK Consulting
Energy Solutions	Phase II screening for biofilm production in ISS microorganisms using CDC bioreactor	Peyton	Jet Propulsion Lab
Energy Solutions	SRF Nickel Treatment Workshop	Peyton	SRK Consulting
Energy Solutions	Eagle 4 SRF EAP Support	Peyton	SRK Consulting
Energy Solutions	F2 Support	Peyton	SRK Consulting
Energy Solutions	REU Site: Exploring the Limits of Life: Understanding Biofilms in Extreme Environments	Peyton	NSF
Energy Solutions	Participation in Organic Carbon in Coal Workshop Sessions with SRK and Teck Coal	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	FMSG: Biologically assembled and Recycled Construction and Structural materials (BRICS)	Heveran	NSF
Medical Biofilms	Synergy between omics, symptoms, and healing trajectories of venous ulcers	Stewart	University of Florida
Medical Biofilms	Development of a predictive moderate throughput assay to screen novel Designer Proline-rich antimicrobial peptide Chaperone protein inhibitors (DPCs) against multi-drug resistant pathogens	James	Arrevis Inc
Medical Biofilms	Intravascular Port and Disinfection System (PortProtek)	James	Hyprotek
Methods Development	Methods to assess biofilm prevention on medical devices	Goeres	Burroughs Wellcome Fund
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
Methods Development	Jayne Morrow	Morrow	Idaho National Laboratory
Modeling	Development of Robust Microbial Communities through Engineered Biofilms	Carlson	ARREOF
Modeling	A Robust Biofilm-Biomat Reactor for Conversion of Mission-Relevant Feedstocks to Products	Carlson	Sustainable Bioproducts
Modeling	A Robust Biofilm-Biomat Reactor for Conversion of Mission-Relevant Feedstocks to Products	Carlson	Sustainable Bioproducts
Physiology & Ecology	Environmental Networks Integrated with Genomes and Molecular Assemblies	Fields	Lawrence Berkley National Laboratory
Physiology & Ecology	R11 Track-2 FEC: Data Driven Material Discovery Center for Bioengineering Innovation	Fields	South Dakota School of Mines
Physiology & Ecology	Maintaining MSU-CBE's World Renown Microscope Facility as State-of-the-Art	Fields	NSF
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	Light Sheet Confocal Microscope - To support biomedical and life science research	Fields	MJ Murdock
Physiology & Ecology	The carbon cost of a healthy root microbiome under environmental stress	Ulrich	UDSA NIFA
Water Systems	Effectiveness of sub irrigation in the Milk River floodplain, MT	Lauchnor	Aaniih Nakoda College
Water Systems	104B State Water Resources Research Institute Program	Kirkland	US Geological Survey

FY21 New CBE Research Grants (July 1, 2020 to June 30, 2021)

New CBE Research Grants Awarded in Fiscal Year 2020 (July 1, 2020 to June 30, 2021)				
Sponsor	Title	PI	Period	Award Amount
Jet Propulsion Lab	Phase II screening for biofilm production in ISS microorganisms using CDC bioreactor	Peyton	1 Yr	\$59,179
US EPA	Statistical Evaluation of Antimicrobial Test Methods and Related Data	Parker	3 Yr	\$128,453
SRK Consulting	Nitrate Dependent Iron Oxidation	Peyton	10 mos	\$22,000
Montana State Government	LAMP: Expanding Screening Capacity to Enhance Montana's COVID-19 Response Capabilities	Connie Chang	3 mos	\$777,799
Idaho National Laboratory	Jayne Morrow	Jayne Morrow	1 mo	\$7,899
NSF	FMSG: Biologically assembled and Recycled Construction and Structural materials (BRICS)	Chelsea Heveran	2 Yrs	\$25,000
City of Bozeman	Bozeman Pilot Wetland - City	Otto Stein	4 Yr	\$30,000
NSF	Maintaining MSU-CBE's World Renown Microscope Facility as State-of-the-Art	Matthew Fields	3 Yr	\$1,081,462
US Department of Defense	Enabling Enhanced Biofilm Imaging for Department of Defense-Related Research at Montana State University and the Northwestern United States	Matthew Fields	1 Yr	\$248,148
NIH	High-Throughput, Massively Parallel Antimicrobial Resistance Surveillance Using Drop-Based Microfluidics	Connie Chang	2 Yr	\$396,000
Hyprotek Inc	Intravascular Port and Disinfection System (PortProtek)	Garth James	2 Yr	\$52,116
MJ Murdock	Light Sheet Confocal Microscope - To support biomedical and life science research	Matthew Fields	1 Yr	\$513,500
USDOE/Impossible Sensing LLC	Spatial Excitation Emission Matrix Spectroscopy instrument (SEEMS)	Christine Foreman	8 mos	\$74,999
SRK Consulting	Participation in Organic Carbon in Coal Workshop Sessions with SRK and Teck Coal	Brent Peyton	1 Yr	\$3,599
	Total Grant Awards to CBE in Fiscal Year 2021			\$3,420,154
	<i>*Additional funding awarded to existing grants in FY21(budget increased by the amount listed)</i>			

FY 2021 New Award Credit to CBE on next page

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New Research Grants with Credit Given to CBE FY2021						
Sponsor	Title	PI	Period	Award Amount	Credit %	Award Ato CBE
Aanih Nakoda College	Effectiveness of sub irrigation in the Milk River floodplain, MT	Ellen Lauchnor	1 Yr	\$23,000	50%	\$11,500
NASA	Early Biofilm Detection in ISS Water Supply Systems using Impedance Microbiology	Stephan Warnat	1 Yr	\$54,648	25%	\$13,662
ULTSafety, Inc	Freedom Chip: High-Speed, Low Cost, High-Throughput Viral Load Detector	James Wilking	4 mo	\$253,736	100%	\$253,736
SRK Consulting	SRF Nickel Treatment Workshop	Brent Peyton	1 Yr	\$2,265	100%	\$2,265
SRK Consulting	Eagle 4 SRF EAP Support	Brent Peyton	1 Yr	\$15,000	100%	\$15,000
SRK Consulting	F2 Support	Brent Peyton	2 Yrs	\$1,497	100%	\$1,497
NSF	REU Site: Exploring the Limits of Life: Understanding Biofilms in Extreme Environments	Brent Peyton	3 Yrs	\$397,090	50%	\$198,545
NIH	Sanchez supplement; Integration of mononuclear phagocytes - GOFLOWChip	Connie Chang	3 months	\$79,051	50%	\$39,526
USDA NIFA	The Carbon Cost of a Healthy Root Microbiome Under Environmental Stress	Danielle Ulrich	3 Yrs	\$749,903	21%	\$157,480
NIH	High-throughput droplet qRT-PCR microfluidic platform for quantification of virus from single cells	Connie Chang	1 Yr	\$360,000	50%	\$180,000
Total Grant Credit Awarded to CBE in Fiscal Year 2021						\$873,210

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RESEARCH:
PUBLICATIONS
June 2020–May 2021

NOTE:

2020-001 through 2020-022 are listed in 2020 Appendix

2020 Publications

Hommel, Johannes, **Arda Akyel, Zachary Frieling, Adrienne J. Phillips, Robin Gerlach, Alfred B.**

Cunningham, Holger Class, "A numerical model for enzymatically induced calcium carbonate precipitation," *Appl. Sci.*, 2020, 10(13):4538. 2020-023.

Christen, J. Andrés, **Albert E. Parker**, "Systematic statistical analysis of microbial data from dilution series," *J Agric, Biol, Environ Stats*, 2020. 2020-024.

McGlennen, Matthew, Michael Neubauer, Matthew Drieser, Christine M. Foreman, Stephan Warnat, "Microsensors in icy environments to detect microbial activities," *J Microelectromech Syst*, 2020, 1-7. 2020-025.

Berg, Lenno van den*, **Catherine M. Kirkland, Joseph Seymour, Sarah L. Codd**, Mark C.M. van Loosdrecht, Merle K. de Kreuk, "Heterogeneous diffusion in aerobic granular sludge," *Biotechno Bioeng*, 2020, 1–11. 2020-27.

Kirkland, Catherine M., Julia R. Krug, Frank J. Vergeldt, Lenno van den Berg, Aldrik H. Velders, **Joseph D. Seymour, Sarah L. Codd**, Henk Van As, Merle K. de Kreuk, "Characterizing the structure of aerobic granular sludge using magnetic resonance," *Water Sci Technol*, 2020, 82(4):627-639. 2020-028.

Hulkova, Marketa*, Jana Soukupova, **Ross P. Carlson**, Blahoslav Marsalek, "Interspecies interactions can enhance *Pseudomonas aeruginosa* tolerance to surfaces functionalized with silver nanoparticles," *Colloids and Surfaces B: Biointerfaces*, 2020, 192:111027. 2020-029.

Nizio, Joanna, Jan Sunner, **Iwona Beech**, Krzysztof Ossolinski, Anna Ossolinska, Tadeusz Ossolinski, Aneta Plaza, Tomasz Ruman, "Localization of metabolites of human kidney tissue with infrared laser-based selected reaction monitoring mass spectrometry imaging and Silver-109 nanoparticle-based surface assisted laser desorption/ionization mass spectrometry imaging," *Anal Chem*, 2020, 92(6):4251-4258. 2020-030.

Ferrer-Espada, Raquel*, Susana Sanchez-Gomez, **Betsey Pitts[#], Philip S. Stewart**, Guillermo Martinez de Tejada, "Permeability enhancers sensitize β -lactamase-expressing *Enterobacteriaceae* and *Pseudomonas aeruginosa* to β -lactamase inhibitors, thereby restoring their β -lactam susceptibility," *Intl J Antimicrob Agents*, 2020, 56(1):105986. 2020-031.

Emmert, Simon, Holger Class, **Katherine J. Davis[#], Robin Gerlach**, "Importance of specific substrate utilization by microbes in microbially enhanced coal-bed methane production: A modelling study," *Intl J Coal*, September 2020, 229:103567. 2020-032.

Reichart, Nicholas J., Zackary J. Jay, Viola Krukenberg, Albert E. Parker, Rachel L. Spietz, **Roland Hatzenpichler**, "Activity-based cell sorting reveals responses of uncultured archaea and bacteria to substrate amendment," *ISME*, 2020, 14:2851-2861. 2020-033.

Zambare, Neerja M., Nada Y. Naser[^], Robin Gerlach, Connie Chang, Mineralogy of microbially induced calcium carbonate precipitates formed using single cell drop-based microfluidics, *Sci Rep*, 2020, 10(17535):1-11. 2020-034.

Elser, James J., Chenxi Wu, Angélica L. González, Daniel H. Shain, **Heidi J. Smith**, Ruben Sommaruga, Craig E. Williamson, Janice Brahney, Scott Hotaling, Joseph Vanderwall, Jinlei Yu, Vladimir Aizen, Elena Zizen, Tom J. Battin, Roberto Camassa, Ziu Feng, Hongchen Jiang, Lixin Lu, John J. Qu, Ze Ren, Jun Wen, Lijuan Wen, H. Arthur Woods, Xiong Xiong, Gongliang Yu, Joel T. Harper, Jasmine E. Saros, "Key rules of life and the fading cryosphere: Impacts in alpine lakes and streams," *Global Change Biology*, 2020, 00:1-13. 2020-035.

Emmert, Simon, **Katherine Davis, Robin Gerlach**, Holger Class, "The role of retardation, attachment and detachment processes during microbial coal-bed methane production after organic amendment", *Water*, 2020, 12(11): 3008. 2020-036.

Allkja, Jontana*, Thomas Bjarnsholt, Tom Coenye, Paul Cos, Adyary Fallarero, Joe J. Harrison, Susana P. Lopes, Antonio Oliver, Maria O. Pereira, Gordon Ramage, Mark E. Shirtliff, Paul Stoodley, Jeremy S. Webb, Sebastian A.J. Zaat, **Darla M. Goeres**, Nuno F. Azevedo, "Minimum information guideline for spectrophotometric and fluorometric methods to assess biofilm formation in microplates," *Biofilm*, 2020, 2:100010. 2020-037.

Zea, Luis, Robert J.C. McLean, **Tony A. Rook[±]**, Geoffrey Angle, D. Layne Carter, **Angela Delegard[±], Adrian Denvir[±], Robin Gerlach**, Sridhar Gorti, Doug McIlwaine, Mononita Nur, **Brent M. Peyton, Phillip S. Stewart, Paul Sturman**, YoAnn Velez Justiniano, "Potential biofilm control strategies for extended spaceflight missions," *Biofilm*, 2020, 2:100026. 2020-038.

Mendez, Ellen, **Diane K. Walker**, Jessie Vipham, Valentina Trinetta, "The use of a CDC biofilm reactor to grow multi-strain *Listeria monocytogenes* biofilm," *Food Microbiol*, 2020, 92:103592. 2020-039.

Johnson, Winifred M., Harriet Alexander, Raven L. Bier, Dan R. Miller, Mario E. Muscarella, Kathleen J. Pitz, K., **Heidi J. Smith**, "Auxotrophic interactions: A stabilizing attribute of aquatic microbial communities?," *FEMS Microb Ecol*, 2020, 96(11):fiae115. 2020-040.

Feder, Marnie J.[#], Arda Akyel, Vincent J. Morasko, Robin Gerlach, Adrienne J. Phillips, "Temperature-dependent inactivation and catalysis rates of plant-based ureases for engineered biomineralization," *Eng Rep*, 2020, e12299. 2020-041.

Park, Heejoon[#], Ayushi Patel, Kristopher A. Hunt, Michael A. Henson, **Ross P. Carlson**, "Artificial consortium demonstrates emergent properties of enhanced cellulosic-sugar degradation and biofuel synthesis," *npj Biofilms and Microbiomes*, 2020, 6:59. 2020-042.

Kirkland, Catherine M., Randy Hiebert, Robert Hyatt, Jay McCloskey, Jim Kirksey, **Abby Thane[#], Alfred B. Cunningham, Robin Gerlach**, Lee Spangler, **Adrienne J. Phillips**, "Direct injection of biomineralizing agents to restore injectivity and wellbore integrity," *SPE Production & Operations*:1-8. 2020-043.

Kirketerp-Møller, Klaus, **Philip S. Stewart**, Thomas Bjarnsholt, "The zone model: A conceptual model for understanding the microenvironment of chronic wound infection," *Wound Rep Reg*, 2020, 28(5):593-599. 2020-044.

Urbaniak, Camilla, Season Wong, Scott Tighe, Arunkumar Arumugam, Bo Lium, Ceth W. Parker, Jason M. Wood, Nitin K. Singh, **Dana J. Skorupa, Brent M. Peyton**, Ryan Jensen, Fathi Karouia, Julie Dragon, **Kasthuri Venkateswaran[‡]**, "Validating an automated nucleic acid extraction device for omics in space using whole cell microbial reference standards," *Front Microbiol*, 2020, 11:1909. 2020-045.

Hammack, Rebekah, Paul Gannon, **Christine Foreman**, Elijah Meyer, "Impacts of professional development focused on teaching engineering applications of mathematics and science," *School Science and Mathematics*, 2020, 120(7):413-424. 2020-046.

2021 Publications

Schweitzer, Hannah, Nerea J. Aalto, Wolfgang Busch, Dennis Tin Chat Chan, Matteo Chiesa, Ede; O Elvevoll, **Robin Gerlach**, Kirsten Krause, James J. Moran, Joseph P. Noel, Shalaka Kiran Patil, Yannick Schwab, René H. Wijffels, Angela Wulff, Lise Overeas, Hans C. Bernstein, "Innovating carbon-capture biotechnologies through ecosystem inspired solutions," *One Earth*, January 2021, 4(1):49-59. 2021-001.

McGill, S. Lee, Yeni Yung, Kristopher A. Hunt, Michael A. Henson, Luke Hanley, **Ross P. Carlson**, "*Pseudomonas aeruginosa* reverse diauxie is a multidimensional, optimized, resource utilization strategy," *Sci Rep*, January 2021, 11:1457. 2021-002.

Corredor, Luisa, Elliott P. Barnhart, Albert E. Parker, Robin Gerlach, Matthew W. Fields, "Effect of temperature, nitrate concentration, pH and bicarbonate addition on biomass and lipid accumulation in the sporulating green alga PW95," *Algal Research*, March 2021, 53:102148. 2021-003.

McKay, Luke J., Korinne B. Klingelsmith[^], Adam M. Deutschbauer, William P. Inskeep, **Matthew W. Fields**, "Draft genome sequence of *Methanothermobacter thermautotrophicus* WHS, a thermophilic hydrogenotrophic methanogen from Washburn Hot Springs in Yellowstone National Park, USA," *Microbiol Reso Announc*, February 2021, 10(5):e01157-20. 2021-004.

Loveday, Emma K., Geoffrey K. Zath, Dimitri A. Bikos, Zackary J. Jay, Connie Chang, "Screening of additive formulations enables off-chip drop reverse transcription quantitative polymerase chain reaction of single Influenza A virus genomes," *Anal Chem*, February 2021, 93(10):4365-4373. 2021-005.

Hu, Dehong, Yi Cui, Lye M. Markillie, William B. Chrisler, Qiang Wang, **Roland Hatzenpichler**, Galya Orr, "Counting mRNA copies in intact bacterial cells by fluctuation localization imaging-based Fluorescence In Situ Hybridization (fliFISH)," *Methods Molec Bio*, 2021, 2246:237-247. 2021-006.

Mueller, Rebecca C.[#], Jesse T. Peach, **Dana J. Skorupa**, Valerie Copié, Brian Bothner, **Brent M. Peyton**, "An emerging view of the diversity, ecology and function of archaea in alkaline hydrothermal environments," *FEMS Microbiol Ecol*, 2021, 97(2):fiae246. 2021-007.

Rangel, Tafur^{*}, Albert E., Wendy Rios, Daisy Mejia, Carmen Ojeda, **Ross Carlson**, Jorge M. Gómez Ramírez, Andrés F. González Barrios, "In silico design for systems-based metabolic engineering for the bioconversion of valuable compounds from industrial by-products," *Front Gene*, 2021, 12: 633073. 2021-008.

Walsh, Danica J., Tom Livinghouse, Greg M. Durling, **Adrienne D. Arnold**, Whitney Brasier, Luke Berry, **Darla M. Goeres, Philip S. Stewart**, "Novel phenolic antimicrobials enhanced activity of iminodiacetate prodrugs against biofilm and planktonic bacteria," *Chem Biol Drug Design*, 2021, 97(1):134-147. 2021-009.

Lui, Lauren M., Erica L.-W. Majumder, **Heidi J. Smith**, Hans K. Carlson, Frederick von Netzer, **Matthew W. Fields**, David A. Stahl, Jizhong Zhou, Terry C. Hazen, Nitin S. Baliga, Paul D. Adams, Adam P. Arkin, "Mechanism across scales: A holistic modeling framework integrating laboratory and field studies for microbial ecology," *Front Microbio*, 2021, 12:62422. 2021-010.

Rogowski, Louis W., Jamel Ali, Xiao Zhang, **James N. Wilking**, Henry C. Fu., Min Jun Kim, "Symmetry breaking propulsion of magnetic microspheres in nonlinearly viscoelastic fluids," *Nature Comm*, 2021, 12:1116. 21-011.

Kane, Seth, Abby Thane, Michael Espinal, Kendra Lunday, Hakan Armağan, **Adrienne Phillips, Chelsea Heveran**, Cecily Ryan, "Biomineralization of plastic waste to improve the strength of plastic-reinforced cement mortar," *Materials*, 2021, 14(8): 1949. 2021-012.

Reichart, Nicholas J., Robert M. Bowers, Tanja Woyke, **Roland Hatzenpichler**, "High Potential for Biomass-Degrading Enzymes Revealed by Hot Spring Metagenomics," *Front Microbio*, 2021, 12:668238. 2021-013.

O'Donnell, Jeffrey A., Mark Wu, Niall H. Cochrane, Elshaday Belay, **Matthew F. Myntti**[‡], **Garth A. James**, Sean P. Ryan, Thorsten M. Seyler, "Efficacy of common antiseptic solutions against clinically relevant microorganisms in biofilm," *Bone Joint Surgery*, 2021, 103-B(5):908-915. 2021-014.

Abbasi, Reha, Thomas B. LeFevre, Aaron D. Benjamin, **Isaak J. Thornton, James N. Wilking**, "Coupling fluid flow to hydrogel fluidic devices with reversible "pop-it" connections," *Lab on a Chip*, 2021, 10:2050-2058. 2021-015.

Alvarez, Adriana L., Sharon L. Weyers, **Hannah M. Goemann, Brent M. Peyton**, Robert D. Gardner, "Microalgae, soil and plants: A critical review of microalgae as renewable resources for agriculture," *Algal Research*, 2021, 54:102200. 21-016.

Hunt, Kristopher A., Natasha Mallette, **Brent M. Peyton, Ross Carlson**, "In silico analysis of functionalized hydrocarbon production using ehrlich pathway and fatty acid derivatives in an endophytic fungus," *Journal of Fungi*, 2021, 7(6):435. 2021-017.

Allkja, Jontana, Frits van Charante, Juliana Aizawa, Inés Reigada, Clara Guarch-Pérez, Jesus Augusto Vazquez-Rodriguez, Paul Cos, Tom Coenye, Adyary Fallarero, Sebastian A.J. Zaat, Antonio Felici, Livia Ferrari, Nuno F. Azevedo, **Albert E. Parker, Darla M. Goeres**, "Interlaboratory study for the evaluation of three microtiter plate-based biofilm quantification methods," *Sci Rep*, 2021, 11:13779. 2021-018.

Jackson, Benjamin D., James M. Connolly, **Robin Gerlach**, Isaac Klapper, **Albert E. Parker**, "Bayesian estimation and uncertainty quantification in models of urea hydrolysis by *E. coli* biofilms," *Inverse Problems in Science and Engineering*, 2021, 29(11):1629-1652, 2021-019.

Peyton, Brent, Dana Skorupa, "Integrating CUREs in ongoing research: Undergraduates as active participants in the discovery of biodegrading thermophiles," *Microbiol Biol Ed*, 2021, 22(2): e00102-21. 2021-020.

Foreman, Christine, Mitch W. Messmer, Markus Dieser, Heidi J. Smith, Albert E. Parker, "Investigation of Raman and other spectroscopic signatures with advanced statistics: An approach for cataloguing polar microbes," *Bulletin of the American Astronomical Society*, 53(3). 2021-021.

Goeres, Darla, Stephen Pedersen[‡], **Bryan Warwood**[‡], **Diane K. Walker, Albert E. Parker, Madelyn Mettler, Paul Sturman**. 2020. Design and fabrication of biofilm reactors. In Manuel Simoes, Anabel Borges, and Lucia Chaves Simoes (Eds.), *Recent Trends in Biofilm Science and Technology* (1st ed., pp. 71-88). Academic Press. 2021-022.

[‡] Industrial or Federal Agency co-author

*Previous Visiting Researcher

Previous staff/faculty

[^] Undergraduate Student

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RESEARCH:
PRESENTATIONS (VIRTUAL)
June 2020–May 2021

Connie Chang, assistant professor, chemical and biological engineering, presented her work in the Emergent Properties session of the Biofilm Social Network virtual meeting June 1–5, 2020.

Arda Akyel, PhD student, chemical & biological engineering, was invited to present “Evaluating bacterial ureolysis for the low pH, high temperature and limited oxygen conditions of the deep subsurface,” at the Goldschmidt 2020 virtual meeting, June 21–26, 2020.

Phil Stewart was invited to present “Innate immunity vs nascent biofilm,” at the Biofilms in Health and Disease virtual workshop hosted by the Cardiff Institute and Tissue Engineering and Research Center, Cardiff, Wales, June 24, 2020.

Dana Skorupa, assistant research faculty, chemical & biological engineering, as an invited speaker presented “Some like it hot! Exploring the limits of life on Earth,” for the virtual Bozeman Noon Rotary Club, June 23, 2020.

Darla Goeres, presented “Getting your article published in *Biofilm*,” for an Elsevier Webinar, July 2, 2020.

The following CBE faculty and students presented at the virtual Montana Biofilm Meeting, July 14–16, 2020:

Erika Espinosa-Ortiz, assistant research professor, chemical & biological engineering, presented “Multi-domain biofilm growing systems and their potential application.”

Matthew Fields presented “Identifying causative relationships and active populations in polymicrobial communities.”

Darla Goeres presented “Pathways to innovation: Growing a regulatory science program at the CBE.”

Catherine Kirkland, assistant professor, and **Adie Phillips**, associate professor, both of civil engineering presented “Microbially induced calcium carbonate precipitation (MICP): Bio-cement’s journey from the laboratory to the field.”

Madelyn Mettler, CBE research assistant, presented “Influence of material type and coating on biofilm accumulation by an ISS isolate.”

Brian Pettygrove, PhD candidate, microbiology & immunology, and **Al Parker**, CBE biostatistician

and associate research professor in mathematical sciences, presented “Experimental designs to quantify early aggregation and colonization of biofilms with statistical confidence from confocal images.”

Elinor Pulcini, assistant research professor, chemical & biological engineering, presented “What we know and don’t know about viruses in biofilms.”

Phil Stewart presented “Continued metabolism of bacteria in antimicrobial-treated biofilms.”

Stephan Warnat, assistant professor, mechanical & industrial engineering, presented “Biofilm sensing: An engineering overview.”

Catherine Kirkland was invited to present “Biofilms, oxygen, and wastewater: What chemical gradients can do for you,” at the National Institutes of Health BRIDGES Program held virtually July 17, 2020.

Garth James, associate research professor, chemical & biological engineering, as an invited speaker presented “Biofilm,” at the 2020 virtual Symposium on Advanced Wound Care, July 24–26, 2020.

Dimitri Bikos, CBE postdoctoral researcher, presented “Interfacial additives increase the thermal and mechanical stability of aqueous emulsion droplets for high-throughput microfluidic single-cell influenza studies,” at the American Chemistry Society Fall 2020 Virtual Meeting & Expo, August 17–20, 2020.

Roland Hatzenpichler, assistant professor, chemistry & biochemistry, as an invited speaker presented “Next-generation physiology: Bridging the gap at the single cell level,” at the Joint International Symposium on Microbial and Biomolecular Interactions, Friedrich Schiller University Jena, Sept. 4, 2020.

Maddie Mettler, PhD student, chemical & biological engineering, as an invited speaker presented “Influence of material type and coating on the reduction of biofilm growth of International Space Station isolates,” at the 9th Annual International Space Station Research and Development Conference, Sept. 22, 2020.

Darla Goeres, Research Professor of Regulatory Science, presented “Proposed standard test method for evaluating antimicrobial urinary catheters,” at the ASTM International E35.15 Subcommittee Webinar, Oct. 1, 2020.

Roland Hatzenpichler presented “Functional activity of microbes revealed through substrate analog probing and stable isotope probing,” for the Department of Land Resources and Environmental Sciences Seminar, Montana State University, Oct. 5, 2020.

Phil Stewart, Regents Professor, chemical & biological engineering, presented “Biomaterial infection and innate immunity,” for the Department of Chemical and Biomolecular Engineering Seminar, University of Houston, Oct. 16, 2020.

George Schaible, PhD student, chemistry & biochemistry, was invited to present “Correlative analysis for improved single cell characterization,” at the Montana Nanotechnology Facility (MONT) Annual Users Meeting, Montana State University, Oct. 19, 2020.

Diane Walker, CBE research engineer, as an invited speaker presented “Laboratory-grown multispecies biofilms & disinfectant efficacy testing,” at the International Association for Food Protection Annual Meeting (IAFP), Oct. 26–28, 2020.

Roland Hatzenpichler presented “New microbes in old habitats: Diversity and activity of archaea in Yellowstone hot springs,” for the Archaea Cafe, Medical University of Graz, Austria, Nov. 18, 2020.

The following CBE undergraduate students presented posters of their research at the Undergraduate Research Symposium at Montana State University, Dec. 3, 2020:

James Gurney, plant science & plant pathology: “Developing screening procedures for microbial conversion of methylamine to methane.” (Mentor: Roland Hatzenpichler)

Michael Espinal, mechanical & industrial engineering: “Exploring the utilization of mineralized fibers to improve the toughness of cement.” (Mentors: Chelsea Heveran, Adrienne Phillips, Cecily Ryan)

Gretchen Gutenberger, chemical & biological engineering: “Understanding microbial interactions in fungal-bacterial biofilms: Implications for environmental remediation.” (Mentors: Erika Espinosa-Ortiz, Robin Gerlach, Ellen Lauchnor)

Lillian Heys, microbiology & cell biology: “Comparing growth rates of *Pseudomonas aeruginosa* and *Staphylococcus aureus* in single-cell and bulk cultivation approaches.” (Mentor: Connie Chang)

Matalin Pirtz, chemical & biological engineering: “The effects of chemokines on dendritic cell movement out of Matrigel.” (Mentor: Connie Chang)

Roland Hatzenpichler presented “Next-generation physiology: Studying the activity and physiology of uncultured microbes,” for the NSF Center for Dark Energy Biosphere Investigations. Dec. 3, 2020.

Joe Seymour, professor, chemical & biological engineering, as an invited speaker presented “Magnetic resonance imaging measurements of mass and energy transport: Oxygen transport in microbially impacted porous media and energy transport by forced and natural convection in packed beds,” American Geophysical Union Fall Meeting (H001-06), Dec. 7, 2020.

The following CBE faculty and staff presented their research at the CBE Pathways to Product Development Annual Meeting, Feb. 1–3, 2021:

Darla Goeres: “Pathways to Innovation: Update on the CBE Regulatory Science Program.”

Garth James, associate research professor, chemical & biological engineering: “Effects of a cadexomer iodine wound gel on viability, oxygen penetration and pH in mature in-vitro *Pseudomonas aeruginosa* and *Staphylococcus aureus* biofilms.”

Al Parker, CBE biostatistician: “Statistical techniques for analyzing presence and absence data from microbes: MPN and TCID50 (invited talk);” and “A statistical assessment of standard methods: Case studies of ASTM, CDC, STM & MBEC biofilm methods” (workshop).

Phil Stewart: “The shield hypothesis of biofilm chronic infections.”

Diane Walker: “CBE online biofilm resources.”

Darla Goeres, was invited to present “US EPA regulatory guidance: “The path to anti-biofilm products in the marketplace,” at the Microbes and Biofilms in the Food Industry conference, hosted by National Biofilms Innovation Centre & Society for Applied Microbiology, Feb. 4, 2021.

Ross Carlson, professor, chemical & biological engineering, as an invited speaker presented “Multiscale analysis of autotroph-heterotroph interactions in a microbial community,” 2021 American Association for the Advancement of Science (AAAS) Annual Meeting, Feb. 9, 2021.

Brent Peyton, professor, chemical & biological engineering, presented “How-and-why: Do natural microbes remove nitrate and selenium from mine-affected water?” at the Kamloops Exploration Mining Group Virtual KEG Lecture Series, April 8, 2021.

The following CBE PhD Students presented their research for MSU’s Department of Microbiology & Cell Biology 2020–2021 Research in Progress Seminar Series:

Adrienne Arnold: “Metabolic modeling of culturing stresses in *Chlorella sorokiniana* SLA-04”.

Katrina Lyon: “Organoid models for the gastric mucosal defense against *Helicobacter pylori*”.

Brian Pettygrove: “Mechanisms of neutrophil evasion by nascent *Staphylococcus aureus* biofilm”.

Joe Seymour was invited to present “MRI of Mass and Energy Transport: Oxygen transport in microbially impacted porous media and energy transport by forced and natural convection in packed beds,” to the Porous Media Group, Departments of Mathematics and Statistics and Civil and Environmental Engineering, Washington State University, Pullman, WA, April 23, 2021.

Diane Walker presented “Sticking Together for Success: An introduction to biofilm and the Center for Biofilm Engineering at Montana State University,” at the 2021 International Society of Beverage Technologists (ISBT - BevTech2021), April 26–May 13, 2021.

Roland Hatzenpichler as an invited speaker presented “Next-generation physiology: Why and how to measure microbial phenotypes under (close to) in situ conditions,” Center for Dark Energy Biosphere Investigations Virtual Meeting, May 7, 2021.

CBE faculty participated in the 3rd International Conference on Biofilms-Asia-Pacific Biofilms 2021, held virtually from Guangzhou, China, May 11–16, 2021:

Robin Gerlach, professor, chemical & biological engineering, as an invited keynote presented, “Biofilm-mineral interactions: Insights from engineered biomineralization applications and the urinary tract.”

Darla Goeres as an invited speaker presented “Biofilm Standard Methods: Enabling for innovation in the marketplace,” and hosted the workshop “Standard Methods for Growing Biofilms.”

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RESEARCH:

CBE Affiliated Faculty and Their Specialties, 2020–2021

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

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

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RESEARCH:
NEWS HIGHLIGHTS

NSF funds CBE microscopy upgrade

A \$1.5 million microscope upgrade will allow CBE researchers to peer noninvasively deeper into intact biofilm samples. This customized microscope will be the first of its kind in the Northwest. [Read more about how this new equipment will advance biofilm research](#)

CBE part of MSU team developing new, complementary COVID-19 testing method

A new grant from the state of Montana will support Montana State University researchers as they explore a faster and less costly method for COVID-19 testing which, when used in conjunction with existing testing methods, could ultimately improve the access to and the speed of testing. [Read more about this opportunity for more efficient testing](#)

Team of CBE researchers receive grant to make fungus-based building material

Backed by a \$500,000 grant from NSF, a team of scientists at the CBE will explore the potential for using fungi to make a recyclable building material that could have several advantages over traditional concrete. [Read more about this new approach to building materials](#)

CBE microbiologist looking deeper into biology of ‘Asgard’ microbes

CBE affiliated faculty member Roland Hatzepichler, assistant professor in chemistry and biochemistry, is furthering the search for the origin of complex life by studying microbes with the potential to change our ideas on how organisms evolved. [Read more about the important work being done with Asgard archaea](#)

3D printing capabilities at CBE are opening new doors for microfluidics

Where two of the hottest fields in engineering intersect, Montana State University researchers have made a small breakthrough — literally — but one that could have a big impact across a wide range of applications. [Read more about these low-cost sensors that have potential for use in environmental and industrial applications](#)

CBE expanding biofilm research capabilities with grant from Murdock Trust

A new grant from the M. J. Murdock Charitable Trust will support ongoing efforts by Montana State University to significantly upgrade microscopy equipment, fostering world-class biofilm research aimed at, among other things, preventing metal corrosion, treating life-threatening infections, and stopping leaks in oil and gas wells. The \$513,000 will allow the CBE to purchase a roughly \$1.5 million custom-made microscope. [Read more](#)

Yellowstone Public Radio features CBE project on sustainable concrete

Yellowstone Public Radio recently highlighted a project being conducted by CBE researchers **Erika Espinosa-Ortiz, Robin Gerlach, Chelsea Heveran, and Adie Phillips** who are seeking ways microorganisms might be used to form sustainable concrete. [Read more](#)

CBE featured as early success story in NSF ERC history book

A new book detailing the history of the NSF’s Engineering Research Center program prominently features the Center for Biofilm Engineering as an early success story. NSF and the American Society for Engineering Education published *Agents of Change: NSF’s Engineering Research Centers* in August 2020. **Courtland Lewis** and **Lynn Preston** wrote the 700-page book, which is available to read at no charge online. The CBE is mentioned in nine of the book’s 12 chapters. [Read more](#)

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MSU students build device to study biofilm formation in pipes on space station

When **Stephan Warnat**, CBE affiliated faculty in mechanical engineering, set out to help solve a longstanding problem on the International Space Station, he turned to a group of four mechanical engineering majors. During a recent Montana Biofilm Meeting hosted by CBE, Warnat learned from NASA scientists that microbial buildup

sometimes clogs the space station's water pipes—a demanding challenge for astronauts to fix. A specialist in tiny sensors used to measure, among other things, water quality, Warnat wanted to study how the microbes grow. He just needed a research device that could simulate the microgravity of low Earth orbit. [Read more](#)

CBE researchers find potential use for recycled plastic in concrete

In a recent study, researchers in MSU's Norm Asbjornson College of Engineering found that plastic treated with certain bacteria could be added to concrete in significant quantities without compromising the structural material's strength. [Read more](#)

Expanding biofilm research capabilities with \$513,000 grant from Murdock Trust

A new grant from the M. J. Murdock Charitable Trust will support ongoing efforts by Montana State University to significantly upgrade microscopy equipment, fostering world-class biofilm research aimed at, among other things, preventing metal corrosion, treating life-threatening infections, and stopping leaks in oil and gas wells.

The \$513,000 will allow the Center for Biofilm Engineering in MSU's Norm Asbjornson College of Engineering to purchase a roughly \$1.5 million custom-made microscope. CBE also recently received \$1 million for the versatile microscope through the National Science Foundation's Major Research Instrumentation program. [Read more](#)

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CBE Affiliated Faculty & Staff Awards & Appointments

2021 College of Engineering Awards

Four faculty and one staff member of the Center for Biofilm Engineering received awards during the 2021 Norm Asbjornson College of Engineering Faculty/Staff Award Ceremony, held virtually for the second consecutive year. The CBE recipients are listed alphabetically.

Connie Chang, assistant professor of chemical & biological engineering, won the Excellence in Research (Faculty) Award.

“Since her tenure track appointment, and with very limited resources in terms of startup funding, Dr. Chang has developed a vibrant research group now comprises one of the largest and well-funded labs in our department,” wrote Abigail Richards, department head of chemical & biological engineering, in her letter nominating Chang for the award. “Dr. Chang has been a part of 55 submitted research proposals, including 38 on which she was PI. When including grants on which Dr. Chang is a Co-PI or Co-I, she has contributed to more than \$15.8 million of funded research with a total of \$2.75 million in direct costs to the Chang lab in the last 5 years.” Chang’s research specialties include soft-matter physics and drop-based microfluidics.

Kevin Cook, professor of mechanical & industrial engineering, won the Excellence in Advising Award. Cook’s research emphasis is tool and machine design.

“Kevin has been in charge of the Mechanical Engineering Technology program for 25 years and advised hundreds of students in that major. He is assigned approximately 40 MET students as advisees each semester but sees many more than that throughout each semester. Kevin is the heart and soul of MET advising,” wrote Sarah Codd, professor of mechanical & industrial engineering, in her letter nominating Cook for the award. “If you stand outside his office anytime of the day it is clear he enjoys this part of his job and feels that it is a great way to make a difference in young people’s lives. You can just hear the energy he puts into his connections with students.”

Erika Espinosa-Ortiz, assistant research professor of chemical & biological engineering, won the Excellence in Research (Professional) Award. Espinosa-Ortiz’s research interests include fungi and multi-domain biofilm formation.

“Erika has a background in fungal biofilms, which has single-handedly driven forward the multi-kingdom biofilm work at the Center for Biofilm Engineering. [Her current work is] supported by Dow Chemical Company, Sherwin-Williams Company, and Masco Corp., all three current industrial associates of the Center for Biofilm Engineering,” wrote Abigail Richards, department head of chemical & biological engineering, in her letter nominating Espinosa-Ortiz for the award. “Her initial work focusing on fungal-bacterial biofilms was so convincing that the industrial associates decided to support a second phase of this work. Erika’s work has the potential to propel the CBE’s activities into a highly relevant area of research, development, and technology transfer.”

Espinosa-Ortiz’s expertise lies in fungal-based technologies for water and soil remediation, and also encompasses biomineralization processes such as those causing kidney stones and the deterioration of building materials due to biofilm formation.

Steve Fisher, research assistant, won the Classified Employee Award for Excellence. Fisher’s research specialty is medical biofilms. His work often includes conducting testing projects for companies.

“This type of work demands innovation and flexibility and typically involves short timelines and high expectations for results,” wrote four researchers at the CBE, including center director Matthew Fields, in the letter nominating Fisher for the award. “These projects also often require working long or unusual hours. Steve’s efforts on these projects have been exemplary. He completes projects within the expected timeline and often completes them earlier than expected. He often seeks additional work, such as evaluation of new protocols and microscopy stains, when other responsibilities have been properly met. He serves as a great role model for students and other staff.”

Otto Stein, professor of civil engineering, won the Distinguished Professor Award. Stein’s research emphasis is engineered waste remediation.

“Professor Stein’s activities and accomplishments are impressive and support his formal recognition as this year’s NACOE Distinguished Professor. But a summary of his accomplishments would not be complete without recognizing his warmth, his compassion, his positive attitude, and his concern for others. He is truly a model colleague always ready to help advise a student, serve on a committee, and most importantly mentor and collaborate with other faculty,” wrote Craig Woolard, head of the Department of Civil Engineering, in the letter he wrote nominating Stein for the award. “Professor Otto Stein defines ‘distinguished professor.’ He is passionate about his job, supportive of his students and colleagues, and has made outstanding positive contributions to the research, teaching, and service missions of the NACOE and MSU. He is exceptionally deserving of being recognized as the 2021 NACOE Distinguished Professor.”

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2021 CBE Outstanding Faculty Award

Connie Chang, associate professor in chemical and biological engineering, and **Darla Goeres**, CBE research professor of regulatory science, were both awarded the 2021 CBE Outstanding Faculty award.

Connie was recognized for her ability to keep her research group in full, safe operations during the pandemic while also securing significant CARES Act funding for the implementation of asymptomatic screening for SARS-CoV2 on campus. Connie used this opportunity to pour support and funding into the CBE, mobilizing support staff to get the project off the ground. Connie demonstrates her dedication to the CBE by thoughtfully utilizing center resources and support staff on projects, bringing to the CBE notably large grants, mentoring students, and creating a lab group that works exceptionally well together.

Darla was honored for her obvious and unmatched dedication to the Center. Darla prioritizes the legacy

of the center through her networking and collaborations, her focus on member recruitment and retainment, investing in center improvements, and sharing technical skills. Darla has a keen awareness of people's strengths and is excellent at putting teams together to ensure successful deliverables. She values her staff and builds them up and guides them towards improvement and success.

2021 Outstanding Researcher Award

Liz Sandvik, CBE research engineer, received the CBE Outstanding Staff Award. Liz's progress on the CBE's NASA-funded project on biofilm mitigation in the water processor assembly on the ISS has been exemplary. Her work was a major contributing factor to the extension of that funding and the securing of a NASA-EPSCoR grant on biofilm control strategies for water systems during extended space flight. It is especially noteworthy that these successes came amid the restrictions and closures due to the COVID-19 pandemic. Beyond her phenomenal laboratory progress and poise, we greatly appreciate Liz's effective communication efforts, teamwork, and mentoring qualities.

New Staff

In fall 2020, the CBE welcomed **Zahra Mahdiah** to Dr. **Jim Wilking's** lab as a postdoctoral researcher. Zahra earned her PhD in materials science from the University of Montana. During her doctoral work, she developed electrospun fibers with core-shell structure for controlled and prolonged drug delivery applications. An application of the fiber mesh is for wound dressing with smart delivery of antibacterial and wound healing drugs. In Dr. Wilking's lab, Zahra is working to develop a microchip that is a better representative of the human intestine. Zahra is originally from Isfahan, Iran and came to Montana in 2015 for her PhD. A self-confessed bookworm, Zahra's favorite writers are J.K. Rowling, Franz Kafka, and the Iranian poet Forough Farrokhzad, just to name a few. Welcome, Zahra!

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EDUCATION:

Undergraduate Students: Summer 2020, Fall 2020, Spring 2021

*Graduating

*Native American

1.	*Angyus, Michael (Gerlach/Wiedenheft)	M	Chemical & Biological Engineering	Portland, OR
2.	Bauer, Katie (Catherine) (Peyton)	F	Chemical & Biological Engineering	South Saint Paul, MN
3.	*Bedwell, Sierra (Fields)	F	Microbiology & Cell Biology	S. Lake Tahoe, CA
4.	*Blossom, Tallis (Goeres)	F	Chemical & Biological Engineering	Helena, MT
5.	Boden, Farli (Heveran)	F	Architecture	Sandpoint, ID
6.	*Brasier, Whitney (Goeres)	F	Microbiology & Cell Biology	Erie, CO
7.	Brooks, Ellen (Seymour/Kirkland)	F	Chemical & Biological Engineering	Missoula, MT
8.	Burke, Aspen (Foreman)	F	Chemical & Biological Engineering	Windsor, MA
9.	*Carmody, Caitlin (Cati) (Wilking)	F	Mechanical & Industrial Engineering	Butte, MT
10.	Clark, Kaylin (Gerlach)	F	Mechanical & Industrial Engineering	Parker, CO
11.	*Corey, Isabella (Kirkland)	F	Civil & Environmental Engineering	Eagle, ID
12.	Cummings, Atticus (Wilking)	M	Directed Interdisciplinary Studies	Bozeman, MT
13.	Denny, Nina (Christina) (Lauchnor)	F	Civil & Environmental Engineering	Bozeman, MT
14.	Dreesbach, Hannah (Fields)	F	Microbiology & Cell Biology	Helena, MT
15.	*Driesler, Matthew (Warnat)	M	Mechanical & Industrial Engineering	Terrance, CA
16.	Du, Martina (Carlson)	F	Chemical & Biological Engineering	Kent, WA
17.	DuBois, Camryn (Gerlach)	F	Mechanical & Industrial Engineering	Lake Stevens, WA
18.	*Durling, Gregory (Stewart)	M	Chemistry & Biochemistry	Bozeman, MT
19.	Espinal, Michael (Phillips/Heveran)	M	Mechanical & Industrial Engineering	Vacaville, CA
20.	Fields, Max (James) (Barnhart)	M	Microbiology & Cell Biology	Bozeman, MT
21.	*Gutenberger, Gretchen (Gerlach)	F	Chemical & Biological Engineering	Menomonee Falls, WI
22.	Hemmah, Ashlyn (Peyton)	F	Civil & Environmental Engineering	Leads, SD
23.	Heys, Lillian (Chang)	F	Microbiology & Cell Biology	Bozeman, MT
24.	Holcombe, Charles (Gerlach/Carlson)	M	Chemical & Biological Engineering	Great Falls, MT
25.	Jubenville, John (Wilking)	M	Computer Science	Eagan, MN
26.	Kohl, Sandra (Gerlach/Phillips)	F	Civil & Environmental Engineering	Engelwood, CO
27.	Kozisek, Kayla (Gerlach)	F	Chemical & Biological Engineering	Boise, ID
28.	Kulus, Maggie (Margaret) (Stewart)	F	Mathematical Sciences	Sartell, MN
29.	Langton, Kaely (Phillips)	F	Civil & Environmental Engineering	Woodville, WA
30.	Leonard, Michelle (Goeres)	F	Microbiology & Cell Biology	Eureka, MT
31.	Martin, Evan (Chang)	M	Chemical & Biological Engineering	Helena, MT
32.	*Martinson, Anna (Phillips)	F	Chemical & Biological Engineering	Gig Harbor, WA
33.	*McAlpine, Kelly (Phillips/Espinosa-Ortiz)	F	Plant Sciences & Plant Pathology	Simsbury, CT
34.	*McCoy, Quintin (Foreman)	M	Chemical & Biological Engineering	Bend, OR
35.	Miller, Madeleine (Warnat)	F	Mechanical & Industrial Engineering	Wasilla, AK
36.	Moody, Maya (Heveran)	F	Chemistry & Biochemistry	Bozeman, MT
37.	Murray, Abigail (Phillips)	F	Civil & Environmental Engineering	Murrieta, CA
38.	Newby, Audrey (James)	F	Microbiology & Cell Biology	Eau Claire, WI
39.	Newhart, Alyssa (James)	F	Chemical & Biological Engineering	Helena, MT
40.	Novak, Ian (Goeres)	M	Chemical & Biological Engineering	Bozeman, MT
41.	Ostrem, Kathleen (Wilking)	F	Ecology	Wilmette, IL
42.	Pearson, Jack (Foreman)	M	Directed Interdisciplinary Studies	Evergreen, CO
43.	Pernat, Madeline (Kirkland)	F	Chemical & Biological Engineering	Louisville, CO
44.	*Petersen, Theodore (Goeres)	M	Mechanical & Industrial Engineering	Los Alamos, NM
45.	*Pirtz, Matalin (Chang)	F	Chemical & Biological Engineering	Billing, MT
46.	*Prewitt, Olivia (Lauchnor)	F	Civil & Environmental Engineering	Spokane, WA
47.	*Rosenleaf, Joby (Fields)	F	Chemical & Biological Engineering	Butte, MT
48.	*Rotert, Jacob (Stewart)	M	Chemical & Biological Engineering	Everett, WA
49.	Rux, Kylee (Heveran)	F	Civil & Environmental Engineering	Billings, MT
50.	*Sen, Taha Alper (Gerlach)	M	Civil & Environmental Engineering	Bozeman, MT
51.	Shikany, Jonathan (Peyton)	M	Chemical & Biological Engineering	Bellingham, WA

52. Shonka, Jack (Gerlach/Stein)	M	Civil & Environmental Engineering	Williamsburg, VA
53. Stevens, Sage (Goeres)	F	Microbiology & Cell Biology	Green Mountain Falls, CO
54. †Stewart, Tillie (Lauchnor)	F	Microbiology & Cell Biology	Lodge Grass, MT
55. *Stine, Delaney (Wilking)	F	Chemical & Biological Engineering	Buffalo, NY
56. Strautmanis, Uve (Fields)	F	Microbiology & Cell Biology	Cedarburg, WI
57. Taylor, Molly (Gerlach)	F	Civil & Environmental Engineering	Bozeman, MT
58. Teska, Christy (Foreman)	F	Chemical & Biological Engineering	Stow, MA
59. Turner, Evan (Goeres)	M	Chemical & Biological Engineering	Honolulu, HI
60. Wait, Kaylan (Wilking)	F	Chemical & Biological Engineering	Durango, CO
61. *Valenzuela, Mary (Lauchnor/Eggers)	F	Microbiology & Cell Biology	Soldotna, AK

Undergraduates Summary: 2020–2021

Department	Male	Female	Total
Architecture		1F	1
Chemical & Biological Engineering	8M	15F	23
Chemistry & Biochemistry	1M	1F	2
Civil & Environmental Engineering	2M	9F	11
Computer Science	1M		1
Directed Interdisciplinary Studies (Honors College)	2M		2
Ecology		1F	1
Mathematical Sciences		1F	1
Mechanical & Industrial Engineering	3M	4F	7
Microbiology & Cell Biology	1M	10F	11
Plant Sciences & Plant Pathology		1F	1
Totals	18M	43F	61

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EDUCATION:

Graduate Students: Summer 2020, Fall 2020, Spring 2021

‡ Native American *Received degree

Masters Candidates

1.	*Ajayi, Kehinde (Wilking)	M	Mathematical Sciences	Lagos, Nigeria
2.	Ayotte, Stephanie (Stein)	F	Civil & Environmental Engineering	Saco, ME
3.	*Bowman, Tucker (Stein)	M	Civil & Environmental Engineering	Highland Ranch, CO
4.	Dudiak, Cameron (Wilking/McCalla)	M	Mathematical Sciences	Boulder, CO
5.	*Golichnik, Joseph (Gerlach)	M	Civil & Environmental Engineering	Neenah, WI
6.	Gunyol, Pinar (Phillips)	F	Civil & Environmental Engineering	Ankara, Turkey
7.	*Karcher, Paul (Stein)	M	Civil & Environmental Engineering	Cut Bank, MT
8.	Kilic, Ayse Bengisu (Lauchnor)	F	Chemical & Biological Engineering	Istanbul, Turkey
9.	*Kronz, Shannon (Kirkland)	F	Civil & Environmental Engineering	N. Olmsted, OH
10.	Lyon, Katrina (Wilking/Bimczok)	F	Microbiology & Cell Biology	Highwood, IL
11.	*Neubauer, Michael (Warnat)	M	Mechanical & Industrial Engineering	Rogers, MN
12.	Massey, KaeLee (Fields)	F	Chemical & Biological Engineering	Billings, MT
13.	*Panighetti, Robert (Stein)	M	Civil & Environmental Engineering	Cedarburg, WI
14.	Ritu, Tasnim Sultana (Kirkland)	F	Civil & Environmental Engineering	Joypurhat, Bangladesh
15.	*Thomae, Madelyn (Warnat)	F	Mechanical & Industrial Engineering	Ashland, OH
16.	*Thompson, Luke (Stein)	M	Civil & Environmental Engineering	Littleton, CO
17.	Willett, Matthew (Kirkland)	M	Chemical & Biological Engineering	Puyallup, WA
18.	*Zeng, Jason (Wilking)	M	Chemical & Biological Engineering	Novato, CA

PhD Candidates

1.	*Abbasi, Reha (Wilking)	M	Chemical & Biological Engineering	Istanbul, Turkey
2.	Akyel, Arda (Gerlach)	M	Chemical & Biological Engineering	Istanbul, Turkey
3.	Anjum, Sobia (Gerlach)	F	Chemical & Biological Engineering	Punjab, Pakistan
4.	Arnold, Adrienne (Carlson)	F	Microbiology & Cell Biology	Charleston, WV
5.	Bodle, Kylie (Kirkland)	F	Civil & Environmental Engineering	Camano Island, WA
6.	Brown, Madelaine (Stewart)	F	Chemical & Biological Engineering	San Jose, CA
7.	Casey, Cailin (Heveran)	F	Mechanical & Industrial Engineering	Melbourne, FL
8.	Christian, William (Hatzenpichler)	M	Chemistry & Biochemistry	Grand Rapids, MI
9.	Cicha, Calvin (Gerlach/Wiedenheft)	M	Microbiology & Cell Biology	Isanti, MN
10.	Fredrickson, Jacob (Chang)	M	Chemical & Biological Engineering	Puyallup, WA
11.	Goemann, Hannah (Peyton)	F	Microbiology & Cell Biology	Wells, MN
12.	Hislop, Brady (Heveran)	M	Mechanical & Industrial Engineering	Polson, MT
13.	Hoffman, Carter (Chang)	M	Chemical & Biological Engineering	Carlsbad, CA
14.	*Jackson, Matthew (Gerlach)	M	Chemical & Biological Engineering	Naples, FL
15.	Kane, Seth (Ryan/Phillips)	M	Mechanical & Industrial Engineering	Fairbanks, AK
16.	Koenig, Heidi (Stewart/Livinghouse)	F	Chemistry & Biochemistry	Everett, WA
17.	Koepnick, Hannah (Peyton)	F	Chemical & Biological Engineering	Sherman, TX
18.	Kohtz, Anthony (Hatzenpichler)	M	Chemistry & Biochemistry	Omaha, NE
19.	LeFevre, Thomas (Wilking)	M	Chemical & Biological Engineering	Escanaba, MN
20.	Lynes, Mackenzie (Hatzenpichler)	F	Chemistry & Biochemistry	Cleveland, OH
21.	McGill, Lee (Carlson)	M	Microbiology & Cell Biology	Minor Hill, TX
22.	McGlennen, Matthew (Warnat/Foreman)	M	Mechanical & Industrial Engineering	Edina, MN
23.	Mettler, Madelyn (Peyton)	F	Chemical & Biological Engineering	Littleton, CO
24.	Meyer, Maranda (Wilking/Ryan)	F	Mechanical & Industrial Engineering	Edmonton, Alberta
25.	Miller, Isaac (Fields)	M	Microbiology & Cell Biology	East Helena, MT
26.	*Moll, Karen (Peyton)	F	Microbiology & Cell Biology	Fairport, NY
27.	Pettygrove, Brian (Stewart)	M	Microbiology & Cell Biology	Leesburg, VA
28.	Pratt, Shawna (Chang)	F	Chemical & Biological Engineering	Miles City, MT
29.	Rathore, Muneeb (Peyton)	M	Chemical & Biological Engineering	Punjab, Pakistan

30. Reichart, Nicholas (Hatzenpichler)	M	Chemistry & Biochemistry	Bel Air, MD
31. Sanchez, Humberto (Chang)	M	Chemical & Biological Engineering	Corona, CA
32. Schaible, George (Hatzenpichler)	M	Chemistry & Biochemistry	Missoula, MT
33. Shabazian, Andre (Stewart)	M	Chemistry & Biochemistry	Palo Alto, CA
34. Thomas, Mallory (Chang)	F	Microbiology & Cell Biology	Elkhart, IN
35. Thornton, Isaak (Wilking)	M	Mechanical & Industrial Engineering	Great Falls, MT
36. Vahidi, Ghazal (Heveran)	F	Mechanical & Industrial Engineering	Tehran, Iran
37. Welhaven, Hope (Heveran)	F	Chemistry & Biochemistry	Billings, MT
38. Willis, Madie (Madelyne) (Foreman)	F	Land Resources & Environmental Sciences	Atlanta, GA
39. *Zath, Geoffrey (Chang)	M	Chemical & Biological Engineering	Bend, OR
40. Zimlich, Kathryn (Fields)	F	Microbiology & Cell Biology	Dublin, OH

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**EDUCATION:
 Graduate Students, 2020–2021**

18: Chemical & Biological Engineering

MS: 4

2 M Willett, Matthew: MS, *Kirkland*
 Zeng, Jason: MS, *Wilking*

2 F Kilic, Ayse Bengisu: MS, *Lauchnor*
 Massey, KaeLee: MS, *Fields*

PhD: 14

9 M Abbasi, Reha: PhD, *Wilking*
 Akyel, Arda: PhD, *Gerlach*
 Fredrickson, Jacob: PhD, *Chang*
 Hoffman, Carter: PhD, *Chang*
 Jackson, Matthew: PhD, *Gerlach*
 LeFevre, Thomas: PhD, *Wilking*
 Rathore, Muneeb: PhD, *Peyton*
 Sanchez, Humberto: PhD, *Chang*
 Zath, Geoffrey: PhD, *Chang*

5 F Anjum, Sobia: PhD, *Gerlach*
 Brown, Madelaine: PhD, *Stewart*
 Koepnick, Hannah: PhD, *Peyton*
 Mettler, Madelyn: PhD, *Peyton*
 Pratt, Shawna: PhD, *Chang*

8: Chemistry & Biochemistry

PhD: 8

5 M Christian, William: PhD, *Hatzenpichler*
 Kohtz, Anthony: PhD, *Hatzenpichler*
 Reichart, Nicholas: PhD, *Hatzenpichler*
 Schaible, George: PhD, *Hatzenpichler*
 Shabazian, Andre: PhD, *Stewart*

3 F Lynes, Mackenzie: PhD, *Hatzenpichler*
 Koenig, Heidi, PhD, *Stewart*
 Welhaven, Hope, PhD, *Heveran*

10: Civil / Environmental Engineering

MS: 9

5 M Bowman, Tucker: MS, *Stein*
 Golichnik, JT: MS, *Espinosa-Ortiz*
 Karcher, Paul: MS, *Stein*
 Panighetti, Robert: MS, *Stein*
 Thompson, Luke: MS, *Stein*

4 F Ayotte, Stephanie: MS, *Stein*
 Gunyol, Pinar: MS, *Phillips*
 Kronz, Shannon: MS, *Kirkland*
 Ritu, Tasnim Sultana: MS, *Kirkland*

PhD: 1

1 F Bodle, Kylie: PhD, *Kirkland*

1: Land Resources & Environmental Sciences

PhD: 1

1 F Willis, Madelyne: PhD, *Foreman*

2: Mathematical Sciences

MS: 2

2 M Ajayi, Kehinde: MS, *Wilking*
 Dudiak, Cam: MS, *Wilking/McCalla*

9: Mechanical & Industrial Engineering

MS: 2

1 M Neubauer, Michael: MS, *Warnat*

1 F Thomae, Madelyn: MS, *Warnat*

PhD: 7

4 M Hislop, Brady: PhD, *Heveran*
 Kane, Seth: PhD, *Ryan/Phillips*
 McGlennen, Matthew: PhD, *Warnat*
 Thornton, Isaak: PhD, *Wilking*

3 F Casey, Cailin: PhD, *Heveran*
 Meyer, Maranda: PhD, *Wilking/Ryan*
 Vahidi, Ghazal: PhD, *Heveran*

10: Microbiology & Cell Biology

MS: 1

1 F Lyon, Katrina: MS, *Wilking*

PhD: 9

4 M Cicha, Calvin: PhD, *Gerlach*
 McGill, Stacy: PhD, *Carlson*
 Miller, Isaac: PhD, *Fields*
 Pettygrove, Brian: PhD, *Stewart*

5 F Arnold, Adrienne: PhD, *Carlson*
 Goemann, Hannah: PhD, *Peyton*
 Moll, Karen: PhD, *Peyton*
 Thomas, Mallory: PhD, *Chang*
 Zimlich, Kathryn: PhD, *Fields*

TOTALS

Total Grads: 58

Total MS: 18 10 M / 8 F

Total PhD: 40 22 M / 18 F

Total Male: 32

Total Female: 26

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EDUCATION:

Graduating with advanced degrees: June 2020–June 2021

Robert Panighetti, MS, Civil & Environmental Engineering, June 2020

Effects of Hydraulic Loading on Nitrification and Denitrification Processes in a Two-Stage, Vertical Flow Treatment Wetland at Bridger Bowl Ski Area

Madison Thomae, MS, Mechanical & Industrial Engineering, July 2020

MEMS Resistance Temperature Devices Designed and Characterized for Subzero and Arctic Applications

Jason Zeng, MS, Chemical & Biological Engineering, December 2020

Title not available

Reha Abbasi, PhD, Chemical & Biological Engineering, April 2021

Improving Transport in Hydrogels for 3D Bioprinting Applications

Karen Moll, PhD, Microbiology & Cell Biology, April 2021

Alkaline Microalgae from Yellowstone National Park: Physiological and Genomic Characterization

Matthew Jackson, PhD, Chemical & Biological Engineering, April 2021

Evaluation of Nitrogen and Carbon Supplementation Strategies for Optimizing Biomass Production During Cultivation of *Chlorella Sorokiniana*, Strain SLA-04

Geoffrey Zath, PhD, Chemical & Biological Engineering, April 2021

Development of Drop-Based Microfluidic Methods for High-Throughput Biological Assays

Luke Thompson, MS, Civil & Environmental Engineering, 2021

Title not available

Tucker Bowman, MS, Civil & Environmental Engineering, 2021

Title not available

Paul Karcher, MS, Civil & Environmental Engineering, 2021

Title not available

Joseph Golichnik, MS, Civil & Environmental Engineering, 2021

Title not available

Shannon Kronz, MS, Civil & Environmental Engineering, 2021

Title not available

Kehinde Ajayi, MS, Mathematical Sciences, 2021

Title not available

EDUCATION:

MSU Student News and Awards

2020 NASA FINESST Award

George Schaible, an MSU-CBE PhD student in chemistry and biochemistry, was awarded a highly prestigious NASA Future Investigators in NASA Earth and Space Science and Technology (FINESST) award. The \$133,000 funding will support three years of Schaible exploring multicellular magnetotactic bacteria, the only known kind of bacteria to be composed of multiple cells throughout its entire life cycle. Schaible was one of only 34 students nationwide who received this honor this year! He is advised by CBE affiliate faculty member Roland Hatzenpichler, assistant professor in chemistry and biochemistry.

CBE undergraduate researcher honored for her leadership, community service

CBE undergraduate researcher **Caitlin (Cati) Carmody** recently won the Excellence in Leadership and Service Award during Montana State University's [98th annual Day of Student Recognition](#). The university also honored 29 other students during the [virtual ceremony](#) held April 26.

CBE Student Awards

2021 W.G. Characklis Outstanding Graduate Student Award

CBE awarded the 2021 W.G Characklis Outstanding Graduate Student Award to Mr. Matthew McGlennen. Matt, a PhD candidate in mechanical and industrial engineering, was recognized for his cross-disciplinary work as an engineer, his leadership skills, strong work ethic, and effectiveness as a collaborator. Matt is also an inventor having developed the design, fabrication, and testing of microfabricated sensors, a platform that is now used by MSU's Microfabrication Facility and will benefit future MSU students. Additionally, Matt pioneered an electrochemical measurement protocol for his work and trained many students across disciplines on how to use this technique in their research. We also take note of Matt's confidence in interacting with CBE stakeholders about how sensor technologies can be applied to various industries.

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

CBE Student Lab Citizen Award

Isaac Miller, PhD candidate in microbiology and cell biology, received CBE's Student Lab Citizen Award. Isaac was recognized for his professionalism, thoughtfulness, and his collaborative and helpful spirit. He is a true team player and a considerate – and fun – lab citizen. His work with microalgae brings him together with a large and diverse group of researchers in many spaces across CBE labs in addition to the collaborations he has forged with staff at the Bozeman Fish Technology Center. He goes out of his way to help with “dirty work” tasks in the Fields Lab, the algae group, and in the CBE, including cleaning, moving equipment and furniture, making group stocks, and something unknown at the Fish Center that causes him to smell very bad at times.

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

2021 MSU Student Research (virtual) Celebration: CBE Participants

MSU's undergraduate and graduate students shared their research at the annual Student Research Celebration Thursday, April 15, 2021. Among the more than 150 students virtually presenting their research, numerous students were connected with the Center for Biofilm Engineering.

Hannah Dreesbach: Microbiology & Immunology

Mentor: Matthew Fields – Microbiology and Immunology

Determining the Effects of Flow Rate on Microbial Localization and Metabolism in a Simulated in situ Terrestrial Subsurface Environment

Michael Angyus: Chemical & Biological Engineering

Mentor: Blake Wiedenheft, Robin Gerlach – Microbiology & Immunology, Chemical & Biological Engineering

New High pH High Alkaline Adapted Microalgae for Biofuel Production

Catherine Bauer: Chemical & Biological Engineering

Mentor: Brent Peyton – Chemical Engineering

Method Development for Measuring Bacterial Growth in Iron-Precipitate Containing Cultures & Growth Comparisons for Nitrate Dependent Fe(II) Oxidation

Christina Denny: Center for Biofilm Engineering

Mentor: Ellen Lauchnor, Christopher Allen – Civil and Environmental Engineering

Observations of Carbon and Nitrogen Removal in Treatment Wetlands

Martina Du: Chemical & Biological Engineering

Mentor: Ross Carlson – Chemical and Biological Engineering

Optimizing Exchange Economics in Synthetic Microbial Ecology Systems

Michael Espinal: Mechanical & Industrial Engineering

Mentor: Chelsea Heveran, Adrienne Phillips – Mechanical & Industrial Engineering, Civil Engineering

Evaluation of the Interfacial Bond Between OPC Mortar and Biomineralized Waste Plastic

Emily Heskett: Environmental Engineering

Mentor: Adrienne Phillips – Civil Engineering

Impacts of Biomineralization Growth in Cold Temperatures

Samantha Kelderman: Chemical & Biological Engineering

Mentor: Dana Skorupa, Brent Peyton – Center for Biofilm Engineering, Chemical and Biological Engineering

Thermophilic bioconversion of oxidized plastics to value-added products

Kayla Kozisek: Chemical & Biological Engineering

Mentor: Robin Gerlach – Chemical and Biological Engineering

Enzyme Degradation of Algal Cell Walls

Evan Martin: Chemical & Biological Engineering

Mentor: Connie Chang – Chemical and Biological Engineering

Optical barcoding of bacterial cells in single-cell drop-based microfluidics

Quintin McCoy: Chemical & Biological Engineering

Mentor: Christine Foreman, Markus Dieser – Chemical & Biological Engineering, Center for Biofilm Engineering

Reduction of Biofilm Formation in Metal Working Fluids Through Introduction of Organic Quorum Sensing Inhibiting Molecules

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Matalin Pirtz: Chemical & Biological Engineering
Mentor: Connie Chang – Chemical and Biological Engineering
Encapsulation and Growth of Gastrointestinal Organoids in Matrigel

Kylee Rux: Civil Engineering
Mentor: Chelsea Heveran – Mechanical & Industrial Engineering
Does Oil-Contaminated Plastic Impair the Compressive Strength of Biomineralized Cement?

Molly Taylor: Civil Engineering
Mentor: Huyen Bui – Center for Biofilm Engineering
Manipulation of Microbial Communities to Promote Algae Growth

Christy Teska: Chemical & Biological Engineering
Mentor: Christine Foreman, Markus Dieser – Chemical and Biological Engineering, Center for Biofilm Engineering
Investigation of Ice Nucleation Activity of Nano- and Microplastics in Snow and Rain

Ashlyn Hemmah: Ecology
Mentor: Dana Skorupa – Chemical and Biological Engineering
Eliminating Plastic Wastes: Using Thermophiles in the Bioconversion of Pre-Treated Plastics

Maya Moody: Chemistry & Biochemistry
Mentor: Chelsea Heveran – Mechanical and Industrial Engineering
Gut Microbiome Influence on Bone Remodeling and Osteocyte Viability

Jack Pearson: English
Mentor: Christine Foreman, Markus Dieser – Chemical and Biological Engineering, Center for Biofilm Engineering
Procedural Development and Utilization of Phenotype MicroArrays for Microbial Cells

Uve Strautmanis: Microbiology & Immunology
Mentor: Heidi Smith – Microbiology and Immunology
Investigation of Complete Groundwater Denitrification Utilizing an Environmentally Relevant Bacterial Coculture

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EDUCATION:

CBE Seminar Series: Fall 2020

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

Date	Speaker	Affiliation	Title/Topic
Aug 20	No Seminar		
Aug 27	Dr. Hans-Curt Flemming	Professor Emeritus, University Duisburg-Essen, Germany	Are biofilms really the dominant form of life of microorganisms on Earth?
Sept 3	No Seminar		
Sept 10	No Seminar		
Sept 17	Dr. Anne Meyer	Associate Professor, Department of Biology, University of Rochester, NY	Biological architecture: From protective biocrystals to 3D-printed biofilms
Sept 24	Dr. William DePas	Assistant Prof., Dept. of Pediatrics, Div. of Infect. Diseases, U. of Pittsburgh and Children's Hospital of Pittsburgh, PA	How nontuberculous mycobacteria regulate aggregation
Oct 1	No Seminar		
Oct 8	Dr. Rosalind Allen	Professor of Biological Physics at the School of Physics and Astronomy, Edinburgh University	Multiscale analysis of resource allocation in chronic wound biofilms
Oct 15	Brittany Gibbs	Masters Student, Computer Science, MSU	BRAiD: A tool to manage images and data from your biofilm experiments
Oct 22	Dr. Lauren Bakaletz	Distinguished Professor, Nationwide Children's Hospital, Columbus, OH	Development of DNABII protein-targeted therapeutic and prevention approaches for biofilm diseases
Oct 29	Dr. Michael Kühl	Professor, Marine Biology, University of Copenhagen, Denmark	Exploring the biofilm microenvironment
Nov 5	Dr. Fitnat Yildiz	Professor, Microbiology & Environmental Toxicology Dept., Inst. of Marine Sciences, UC Santa Cruz, CA	Mechanisms, regulation, and consequences of <i>Vibrio cholerae</i> biofilm formation
Nov 12	Dr. Rikke Louise Meyer	Associate Professor, Dept. of Bioscience and Interdisciplinary Nanoscience Centre, Aarhus University Centre for Water Technology and iNano, Denmark	The secret life of DNA: A tale of DNA's many roles in biofilm
Nov 19	No Seminar- Last Week of Classes		

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EDUCATION:

CBE Seminar Series: Spring 2021

Montana State University, *Virtual Seminar*, 4:10pm MST

Date	Speaker	Affiliation	Title/Topic
Jan 14	Dr. Paul Sturman	Industrial Coordinator, Center for Biofilm Engineering	The CBE Industrial Associates Program: Our history and forward progress
Jan 21	No seminar		
Jan 28	No seminar		
Feb 4	Dr. Howard Stone	Donald R. Dixon '69 and Elizabeth W. Dixon Professor, Mechanical & Aerospace Engineering, Princeton University	Fluid dynamics of speech: Mechanisms underlying COVID-19 transmission
Feb 11	Dr. Knut Drescher	Professor, Max Planck Institute for Terrestrial Microbiology & Philipps-Universität Marburg	Insights into biofilm growth and function enabled by image cytometry
Feb 18	Dr. Gerhard Herndl	Professor, Chair of Aquatic Biology Microbial Oceanography Group Dept. of Functional and Evolutionary Ecology, University of Vienna	Biofilm microbial communities in surface and deep waters
Feb 25	Dr. Maryam Salehi	Assistant Professor, Civil Engineering, University of Memphis	Investigation of the role of biofilm, plastic surface aging, and water chemistry on lead deposition onto and released from plastics
Mar 4	Dr. Hans Steenackers	Assistant Professor, Microbial and Molecular Systems, KU Leuven, Belgium	Cooperation and competition in biofilms: Novel targets for antimicrobial treatment
Mar 11	Dr. Caitlin Proctor	Asst. Professor, Agricultural and Biological Engineering; Environmental and Ecological Engineering, Purdue University	The biofilms you bathe with
Mar 18	Dr. Kendra Rumbaugh	Professor, Surgery Research, School of Medicine, Texas Technological University Health Sciences Center	Understanding and treating biofilms in wounds
Mar 25	Hans Bernstein	Associate Professor, Biosciences, Fisheries and Economics, The Arctic University of Norway	Hot Lake: A story of salty biofilms, chemical gradients and succession dynamics
Apr 1	Alma Dal Co	Postdoctoral Researcher, Engineering and Applied Sciences, Harvard University	Interaction networks in microbial communities
Apr 8	Luanne Hall-Stoodley	Associate Professor, Microbial Infection and Immunity; Director, BSL3 Program, College of Medicine, The Ohio State University	Airway Infections: aggregates, bacteria, and biofilms
Apr 15	Haluk Beyenal	Paul Hohenschuh Distinguished Professor, Gene and Linda Voiland School of Chemical Engineering and Bioengineering, Washington State University, Pullman, WA	Electrochemical control of wound biofilm infections
Apr 26	No Seminar- Last Week of Classes		

TECHNOLOGY TRANSFER:

Industrial Associates, 2020–21

Bold, new *Small business member

3M
Abradem Corp*
American Chemet*
Baxter Healthcare
BioMendics*
Chem-Aqua
Church & Dwight Company
Clorox
Decon7 Systems*
DeLaval
Earth Science Laboratories*
ICU Medical, Inc.
Kersia
Lonza
Masco Corporation
Next Science
Novozymes
Olympus
Perfectus Biomed*
PPG Industries
Procter & Gamble Company
Quest Medical
SANUWAVE Health*
Sharklet Technologies*
Smith & Nephew
Sterilex*
STERIS
The Sherwin-Williams Company
Zimmer Biomet

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TECHNOLOGY TRANSFER:
Montana Biofilm Meeting
July 14–16, 2020

Tuesday

July 14

9:15–9:25 am

Opening remarks

Matthew Fields, CBE Director,
 Professor, Microbiology & Cell
 Biology, MSU

Paul Sturman, CBE Industrial
 Coordinator

SESSION 1:

Biofilm Dynamics

9:25–9:30 am

Session Introduction

Matthew Fields

9:30–10:00

Regulatory mechanisms and
 effectors leading to biofilm
 dispersion

Karin Sauer, Chair, Dept. of
 Biological Sciences; Co-Director,
 Binghamton Biofilm Research
 Center, Binghamton University

10:00–10:30

Identifying causative
 relationships and active
 populations in polymicrobial
 communities

Matthew Fields

10:30–11:00

What we know and don't know
 about viruses in biofilms

Elinor Pulcini, Assistant Research
 Professor, Chemical & Biological
 Engineering, MSU, CBE

SESSION 2:

CBE Paths Forward

11:30–12:00 pm

State of the CBE

Matthew Fields

12:00–12:30

Pathways to Innovation:

Growing a Regulatory Science
 Program at the CBE

Darla Goeres, Research
 Professor of Regulatory Science,
 MSU; PI Standardized Biofilm
 Methods Laboratory, CBE

12:30–1:00 Discussion

Wednesday

July 15

9:15–9:25 am

Opening Remarks

Matthew Fields

Paul Sturman

SESSION 3:

Biofilm Methods

9:25–9:30

Session Introduction

Darla Goeres

9:30–10:00

Development of a biofilm model
 using in vitro colonized tissue
 models

Samantha Westgate, CEO,
 Perfectus Biomed

10:00–10:30

Biofilm sensing: An engineering
 overview

Stephan Warnat, Assistant
 Professor, Mechanical & Industrial
 Eng., MSU, CBE

10:30–11:00

Experimental designs to quantify
 early aggregation and colonization
 of biofilms with statistical
 confidence from confocal images

Brian Pettygrove, PhD
 Candidate, Microbiology &
 Cell Biology, MSU, CBE
 Al Parker, Biostatistician, CBE;
 Assoc. Research Professor,
 Mathematical Sciences, MSU

SESSION 4:

Field Studies

11:30–11:35

Session Introduction

Paul Sturman

11:30–12:05 pm

Multi-domain biofilm growing
 systems and their potential
 application

Erika Espinosa-Ortiz, Asst.
 Research Professor, Chemical &
 Biological Eng., MSU, CBE

12:05–12:35

Microbially induced calcium
 carbonate precipitation (MICP):
 Bio-cement's journey from the
 laboratory to the field

Catherine Kirkland, Assistant
 Professor, Civil Engineering, MSU,
 CBE

Adie Phillips, Assoc. Professor,
 Civil Engineering, MSU, CBE

12:35–1:05

Large-scale water and facility
 decontamination testing
 capabilities

Steve Reese, Research Engineer,
 Idaho National Laboratory

1:05–1:30 Discussion

Thursday

July 16

9:15–9:25 am

Opening Remarks

Matthew Fields

Paul Sturman

SESSION 5:

Biofilms and Antimicrobials

9:25–9:30

Session Introduction

Phil Stewart, Regents Professor,
 Chemical & Biological Eng., MSU,
 CBE

9:30–10:00

Continued metabolism of bacteria in antimicrobial-treated biofilms

Phil Stewart

10:00–10:30

The *Pseudomonas aeruginosa* biofilm matrix and antimicrobial tolerance

Matt Parsek, Professor, Microbiology, University of Washington

10:30–11:00

The immediate and urgent need for products with broad antimicrobial activity and how to get there

Alicia Tetlak, Director, Biological Sciences, Next Science

11:30–12:00 pm

Evaluation of ND-7901 (HT-01): A fast acting bactericidal antibacterial agent with broad activity

Garrett Moraski, Research Scientist, Chemistry & Biochemistry, MSU

12:00–12:30

A highly effective, broad spectrum disinfectant for use against pathogenic organisms and biofilms in food safety applications

Mark Tucker, Chief Scientific Officer Decon7 Systems

12:30–12:50

Influence of material type and coating on biofilm accumulation by an ISS isolate

Madelyn Mettler, Research Assistant, Chemical & Bio. Eng., MSU, CBE

12:50–1:10

Simulated microgravity experimentation and molecular mechanism behind biofilm formation in ISS isolates

Ceth Parker, Postdoctoral Researcher NASA Jet Propulsion Laboratory

[Download agenda here](#)

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TECHNOLOGY TRANSFER:

**Biofilm Technologies: Pathways to Product Development
 February 2-3, 2021**

Monday, February 1

9:30-10:30 am

A statistical assessment of standard methods: Case studies of ASTM, CDC, STM & MBEC biofilm methods

Al Parker, Biostatistician, CBE; Associate Research Professor, Mathematical Sciences, MSU

10:30-10:45 am

CBE online biofilm resources

Diane Walker, Research Engineer, CBE

11:30-1:30 pm

Virtual Poster Session

Tuesday, February 2

9:15-9:25 am

Opening remarks

Matthew Fields, CBE Director; Professor, Microbiology & Cell Biology, MSU
 Paul Sturman, CBE Industrial Coordinator

9:25-9:25 am

Session Introduction

Garth James, PI, Medical Biofilms Laboratory, CBE; Associate Research Professor, Chemical & Biological Eng., MSU

SESSION 1

Medical Technologies

9:30-10:00 am

High-throughput microplate approach to study bacterial adhesion to topographic features on medical devices such as breast implants

Scott Phillips, Regulatory Research Scientist, Center for Device & Radiological Health US FDA

10:00-10:30 am

Dynamic adaptive response of *Pseudomonas aeruginosa* to clindamycin/rifampicin-impregnated catheters

Kidon Sung, Staff Fellow, Div. of Microbiology, National Center for Toxicological Research, US FDAUS FDA

10:30-11:00 am

The shield hypothesis of biofilm chronic infections

Phil Stewart, Regents Professor, Chemical & Biological Engineering, MSU, CBE

11:00-11:30 am Break

11:30 am-12:00 pm

Testing standards for medical implants with an antimicrobial activity

John Rose, Principal Scientist Smith & Nephew

12:00-12:30 pm

Effects of a cadexomer iodine wound gel on viability, oxygen penetration and pH in mature in-vitro *Pseudomonas aeruginosa* and *Staphylococcus aureus* biofilms
 Garth James

12:30-1:00 pm Break

1:00-2:00 pm

Panel Discussion: What are the components that a test method must contain to be considered relevant for FDA data submission?

Moderator: Garth James, CBE
 Co-moderator: Phil Stewart, CBE
 Petra Kohler Riedi, 3M
 Scott Phillips, US FDA
 John Rose, Smith & Nephew
 Sousan Sheldon, Medical Devices Consultants, LLC

Wednesday, February 3

9:15-9:25 am

Opening remarks

Matthew Fields
 Paul Sturman

9:25-9:25 am

Session Introduction

Darla Goeres, PI, Standardized Biofilm Methods Laboratory; Research Professor of Regulatory Science, CBE

SESSION 2

Surface Technologies

9:30-10:00 am

The secret life of DNA: A tale of DNA's many roles in bacterial biofilms

Rikke Louise Meyer, Assoc. Professor, Bioscience and Interdisciplinary Nanoscience Centre, Aarhus University, Aarhus, Denmark

10:00-10:30 am

The power of nature's enzymes— Tailoring green solutions for biofilm control

Lorena Gonzalez-Palmen, Senior Scientist, Novozymes

10:30-11:00 am

An update on antimicrobial product initiatives at the EPA Microbiology Laboratory

Steve Tomasino, Senior Scientist, Office of Pesticide Programs, US EPA

11:00-11:30 am Break

11:30 am-12:00 pm

Statistical techniques for analyzing presence and absence data from microbes: MPN and TCID50

Al Parker

12:00-12:30 pm

Pathways to innovation: Update on
the CBE regulatory science
program

Darla Goeres

12:30–1:00 pm Break

1:00-2:00 pm

Panel Discussion: Panel Discussion
Biofilm assessment technologies
beyond the viable plate count

Moderator: Darla Goeres, CBE

Co-moderator: Al Parker, CBE

Tajah Blackburn, US EPA

Lise Duran, Sterilex

Tony Rook, Sherwin-Williams

Heidi Smith, CBE

Steve Tomasino, US EPA

[Download agenda here](#)

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TECHNOLOGY TRANSFER: **NEWS HIGHLIGHTS**

CBE Medical Biofilms Lab developing method to evaluate coronavirus survival and disinfection

CBE's Medical Biofilms Laboratory received a Research Expansion Fund award from MSU's VP of Research Economic Development and Graduate Education for the Project "Standard Assay Development for Coronavirus Survival and Disinfection." Lead PI **Garth James** and his team are developing methods using surrogate coronaviruses for the COVID-19 virus (SARS-CoV-2) to evaluate disinfectants and the influence of biofilms on coronavirus fate and persistence.

CBE welcomed new members to its Industrial Associates Program:

[Kersia](#) is an international food-safety company with offices in 25 countries. Based in France, Kersia is a leader in biosecurity and food safety, offering solutions to prevent diseases or contamination in animals and humans alike at every stage of the food supply chain. Kersia also provides aerial surface disinfection in the farming sector, as well as surface disinfection in hospitals and emergency water purification in disaster zones. The company recently acquired Medentech, who was a member of the CBE's IA program in 2018.

"I'm happy to announce that **Earth Science Laboratories** has joined the CBE as our newest small business member," says Paul Sturman, Industrial Coordinator for the CBE. "This new partnership brings our small-business membership total to nine, and our overall membership to 27." [Earth Science Laboratories](#) was founded in 1991 in Bentonville, Arkansas, with the mission of "clean water for the planet through innovative chemistry," according to the company's website. They make disinfectants for the municipal water, recreational water, and agricultural products markets.

[CBE Industrial Associates](#)
[CBE membership](#)

CBE published sixteenth Knowledge Sharing Article (KSA) on Standardized

CBE's Standard Biofilm Methods Lab (SBML) announced their sixteenth Knowledge Sharing Article (KSA) on standardized methods "Antimicrobial Test Methods: Multi-laboratory study design for assessing the reproducibility, repeatability, and responsiveness of an antimicrobial test method." The KSA series focuses on laboratory tests for surface antimicrobials and disinfectants. The articles present ideas that the SBML has explored while developing biofilm methods and collaborating with interdisciplinary research teams. [View the library of KSAs](#)

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TECHNOLOGY TRANSFER:

Industry and Agency Interactions

September 16, 2020: **Al Parker**, CBE biostatistician, presented “Fundamentals of experimental design when studying antimicrobial test methods: case studies of UDM and OECD dried surface test methods,” at STERIS Corporation’s R&D Scientific Engagement virtual event.

October 27, 2020: **Matthew Fields** presented “Biofilms and Beyond,” to 3M (CBE IA member since 2007).

November 5, 2020: **Darla Goeres** presented “Proposed standard method for antimicrobial urinary catheters: Ruggedness test results,” to the National Center for Toxicological Research (NCTR).

November 17, 2020: **Paul Sturman**, CBE industrial coordinator, presented “Biofilm growth and response to antimicrobial treatment,” at the 2020 L’Oreal Americas Virtual Hygiene Week.

November 30, 2020: **Paul Sturman** sat for a podcast “Biofilms and the CBE,” for Nephros, a stage company that develops high performance water purification products to the medical device and commercial markets.

March 5, 2021: **Matthew Fields, Darla Goeres, Garth James, and Paul Sturman** presented “CBE and Biofilm Study,” to Church & Dwight via a WebEx webinar. Church & Dwight has been a member of the CBE Industrial Associate Program since 2002.

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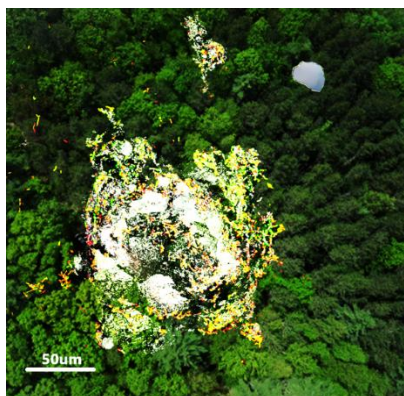
OUTREACH:

News Highlights**CBE faculty take leadership role in summit on minimizing COVID-19 risk in human-built environments**

Matthew Fields, CBE director, and **Darla Goeres**, research professor of regulatory science and head CBE's Standardized Biofilm Methods Laboratory, helped organize and lead an international summit on how people can work together to help minimize the risk of COVID-19 spread in workplaces, schools, and during travel. The Clean 2020 Virtual Summit gathered leaders in business, policy, science, and engineering to understand what is currently known about virus transmission in human-built spaces and how those leaders' fields can work together to control virus transmission. Fields was moderator of the session "Biological surveillance in the built environment—what can we achieve and where do we need innovation?" and Goeres was co-moderator of the session "Decontamination—innovative approaches and chemistry impacts on creating clean and healthy spaces." [Read more about summit](#)

CBE PhD student places in national microscopy image competition

Congratulations to CBE PhD student **Sobia Anjum**! Her image titled "Biomineral Mountain," won 2nd place in the "Most Whimsical" category of a photo contest sponsored by the National Nanotechnology Coordinated Infrastructure.



Sobia's image, above, is a top view of a 3D microscale biomineral mountain: bacterial cells sticking to a self-produced calcium carbonate dome. Some bacteria attach to surfaces and encase themselves in a self-produced gel matrix to form biofilms, which can carry out reactions that alter the pH, thereby precipitating minerals. Here the bacteria are *Sporosarcina pasteurii*, the reaction is ureolysis and the ions are calcium and carbonate, which produce calcium carbonate minerals at alkaline pH. This image shows LIVE/DEAD stained bacterial cells (yellow and red), and reflection of calcium carbonate dome (white). Successive images were collected with depth using a confocal laser scanning microscope and reassembled in silico producing a 3D view.

CBE faculty member helps MSU achieve milestones for females in engineering

CBE-affiliated faculty member **Christine Foreman** has long advocated for female students in a field where men outnumber them by far. So, it felt like a personal victory, she said, when the number of women majoring in engineering and computer science at MSU hit an all-time high. "I'm thrilled with the progress we've made," Foreman says. "I love being able to provide opportunities for young women and watch them exceed their own expectations." [Read more](#)

OUTREACH:

CBE begins annual REU program on extreme biofilms

In 2021 CBE hosted its first year of a three-year REU program on extreme biofilms with MSU's Thermal Biology Institute. The MSU Extreme Biofilms Research Experience for Undergraduates (EB-REU) is a 10-week summer program designed to engage participants in a research project aimed at discovering new ways to grow, understand, and utilize extremophilic biofilms for human benefit. Ten undergraduate scientists will gain a direct appreciation for the unique physical, physiological, and genetic adaptations of biofilm-forming microorganisms found in numerous extreme systems. [Read more about the program](#)

Visiting Researchers

Due to the travel restrictions in place for the SarsCov2 global pandemic, CBE did not host visiting researchers in fiscal year 2021.

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OUTREACH:

Web image library use 2020-2021

Total image downloads: **153**

Requests for CBE graphics were submitted from **18** of the U.S. states:

Arizona	Illinois	Montana
California	Indiana	New York
Colorado	Maryland	South Carolina
Connecticut	Massachusetts	Tennessee
Delaware	Michigan	Texas
Florida	Minnesota	West Virginia

There were requests from an additional **15** countries:

Canada	Germany	Poland
China	India	Portugal
Denmark	Ireland	Syria
Finland	New Zealand	Ukraine
France	Norway	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; a computer lab; and 13 fully equipped research laboratories. General use areas include an analytical instrument lab, a microbiology lab with media preparation area and autoclaves, and a general molecular area with two thermocyclers, a gel running and imaging station, and spectrophotometers for nucleic acid quantification, as well as an isolated radioactive isotope lab. See below for a comprehensive list of shared equipment available.

Microscope Facilities

The microscopy and chemical imaging facilities are coordinated by the Microscopy Facilities Manager who maintains the equipment and trains and assists research staff and students in capturing images of *in situ* biofilms via optical microscopy, fluorescent and Raman confocal microscopy. The microscopy facilities include four separate laboratories—the **Optical Microscopy Lab**, the **Confocal Microscopy Lab**, the **Chemical Imaging Lab**, and the **Microscope Resource Room and Digital Imaging Lab**—which are detailed below.

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

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

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

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

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

The CSLM is capable of imaging biofilms on opaque surfaces, so a wide variety of materials can be used in the experimental flow cells. As biofilm formation proceeds in an experiment, representative areas of the colonized surface are scanned with the use of the automatic stage. Digital data is collected from sequential scans, and stored data can be viewed in the x, y, z coordinates to yield a 3-dimensional image of the biofilm architecture. Quantitative and qualitative information about biofilm architecture can be retrieved easily from examination of CSLM data, in both the x-y and x-z planes, and the existence or absence of structural features, such as microcolonies and water channels, can be determined.

- The **Chemical Imaging Lab** contains a Horiba **Confocal Raman Microscope**. Raman is a vibrational spectroscopic method that provides a fingerprint of the molecular, and to some extent the isotopic composition of a sample. The Horiba LabRam HR Evolution NIR is dedicated to studying the molecular composition of a sample. This is a fully integrated high resolution Raman microscope for confocal Raman analysis, optimized for the visible to IR range (400nm-2500nm) microscope. It includes a confocal Raman microscope with an automated xyz-stage with fast-mapping capabilities, transfer optics, stigmatic spectrometer equipped with two gratings (600 and 1800 l/mm gratings), multichannel air-cooled CCD detector, and computer package with the latest version of the LabSpec6 software and the KnowItAll Raman spectra library, Horiba edition. It is equipped with 532nm 100mW laser, HeNe 633nm laser, 785nm 90mW laser, and 10x, 50x, 100x, 20xLWD and 50xLWD objectives.
- The **Microscope Resource Room / Digital Imaging Lab** is where CBE researchers examine and reconstruct the stacks of image data they have collected using our image analysis software. For quantitative analysis, such as intensity or particle-size measurements, we use Universal Imaging Corporation's MetaMorph software. We use Bitplane's *Imaris* software for computer-intensive data analysis like particle tracking and for qualitative analysis—for example, putting together a stack of 200 red and green flat images to get a 3-dimensional image of a biofilm microcolony that can be rotated in space and examined from every angle. The lab consists of three dedicated computers, a server for storing large files, CD and DVD burners and readers, and a color printer. In addition to providing CBE students, staff, and researchers with an imaging workplace, the resource room gives us a place to hold group tutorials and WebEx group software training sessions.

Mass Spectrometry Facility

In 2005 an equipment grant was awarded for an Environmental and Biofilm Mass Spectrometry Facility through the Department of Defense University Research Instrumentation Program (DURIP). The grant funded the acquisition of an Agilent 1100 series high performance liquid chromatography system with autosampler and fraction collector, an Agilent SL ion trap mass spectrometer, and an Agilent 6890 gas chromatograph (GC) with electron capture detector, flame ionization detector, and 5973 inert mass spectrometer. Since then, an Agilent 7500ce inductively coupled plasma mass spectrometer with autosampler, liquid, and gas chromatographic capabilities have been added as well as an additional Agilent 1100 series high performance liquid chromatography system with autosampler and an Agilent 6890 GC with autosampler and flame ionization detector. The chromatographs and mass spectrometers are very well suited for unknown compound identification and high sensitivity speciation measurements of organic and inorganic compounds; this equipment enhances the CBE's research capabilities significantly. The Environmental and Biofilm Mass Spectrometry Facility is operated as a user facility and allows access for academic and non-academic researchers.

Specialized CBE Laboratories

Ecology/Physiology Laboratory

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

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

Medical Biofilm Laboratory

The Medical Biofilm Laboratory (MBL) has earned a reputation for being a university lab that focuses on industrially relevant medical research in the area of health care as it relates to biofilms. Dr. Garth James (PhD, microbiology), Randy

Hiebert (MS, chemical engineering), and Dr. Elinor Pulcini (PhD, microbiology) have been the innovative leaders and managers of this respected, flexible, and adaptable lab group. The MBL team also includes a full-time research professor, three technicians, and one undergraduate research assistant.

Currently, twelve companies, including CBE Industrial Associates, sponsor MBL projects. These projects include evaluating antimicrobial wound dressings, biofilm formation on biomedical polymers, testing novel toothpaste ingredients, and testing biofilm prevention and removal agents. The MBL is also researching the role of biofilms in Lyme disease with funding from a private foundation. The MBL is a prime example of integration at the CBE, bringing together applied biomedical science, industrial interaction, and student educational opportunities.

Standardized Biofilm Methods Laboratory

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

Microbial Ecology and Biogeochemistry Laboratory

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

Microfluidics Laboratory

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

Microsensor Laboratory

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

OTHER Montana State University facilities available for collaborative research

Montana Nanotechnology (MONT) Facility

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

MSU Nuclear Magnetic Resonance (NMR) Facility

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

MSU Magnetic Resonance Microscopy (MRM) Facility

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

MSU ICAL Laboratory

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

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

The ICAL currently contains eleven complementary microanalytical systems:

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

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

CBE Computer Facilities

The CBE maintains several dedicated computational and data storage computer systems including 10 high performance data and image analysis workstations and servers in addition to three large storage servers. The CBE maintains a small to

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

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