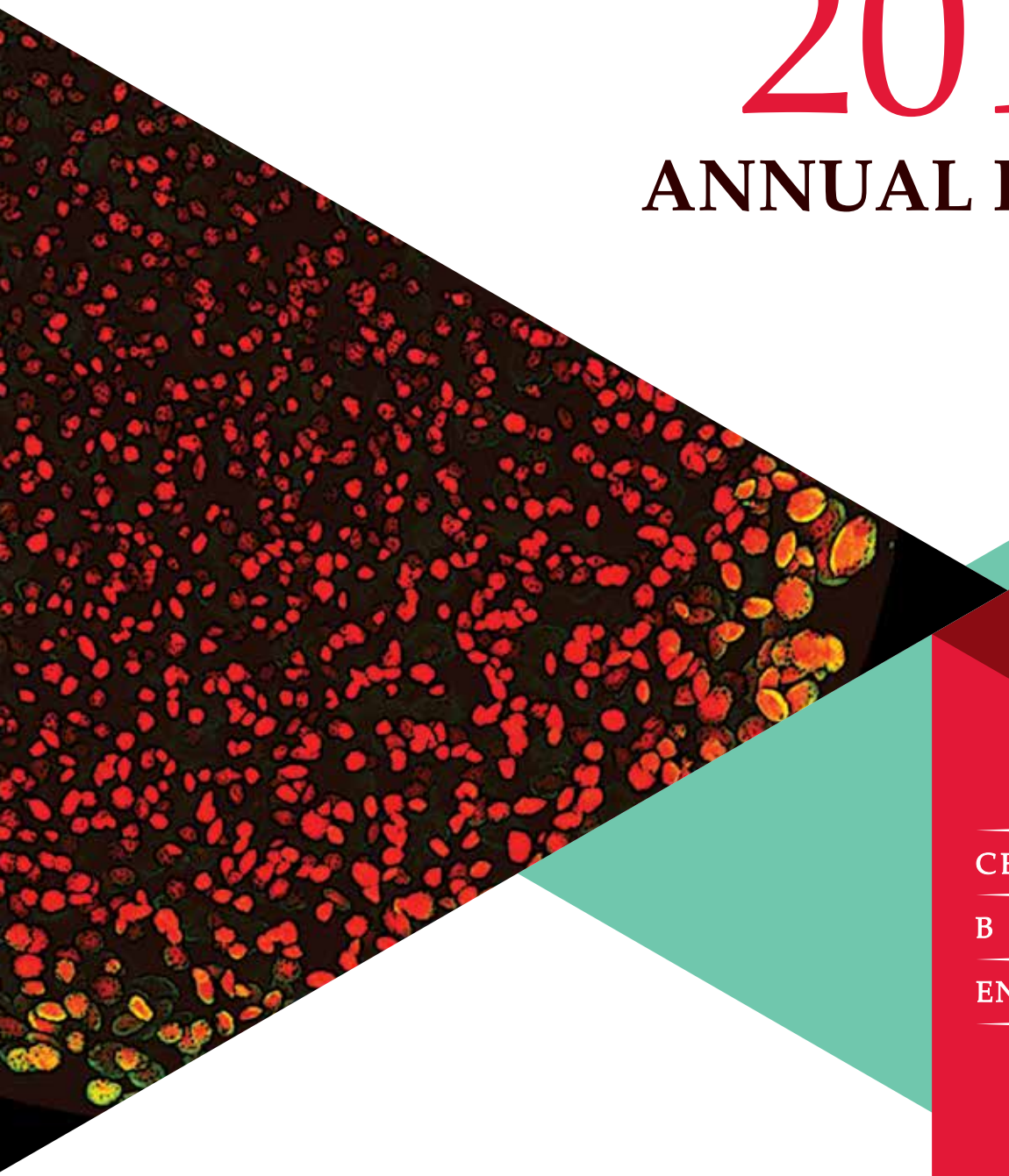
2017
ANNUAL REPORT



CENTER FOR
BIOFILM
ENGINEERING

MONTANA STATE UNIVERSITY | College of ENGINEERING

Scientific achievements, partnerships define 2017

Biofilms continue to impact applied and fundamental aspects of science and engineering, and require multi-interdisciplinary approaches in both research and education in order to address the multitude of complex challenges across pertinent environmental, medical, and industrial fields. Biofilm research continually impacts every-day life through human health, environmental health, energy, food, and water, and the CBE strives to bring the fundamentals of science and engineering research to real-world challenges and opportunities in industry and policy all the while maintaining an inclusive research education environment.

The credit for our successes in 2017 belongs to our talented researchers who are advancing biofilm science every day, and the 62 undergraduate students and 52 graduate students who worked in our laboratories last year. Their important work—some of which you will read about within these pages—empowers industry leaders, medical professionals, and government agencies to help with biofilm challenges and opportunities. In 2017, we hosted our fourth-annual biofilm regulatory meeting in Washington, DC. This meeting continues to be a productive venue for all stakeholders to share emerging technologies and the process for product development. With the support of our 29 Industrial Associates, we'll be hosting this meeting again in 2018.

The CBE faculty, staff, and students look forward to new and continued collaborations and exciting research and outreach in the upcoming year.

Matthew Fields, PhD
Director of the Center for Biofilm Engineering
Professor, Department of Microbiology and Immunology

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ASSOCIATED FACULTY

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Elliott Barnhart
Center for Biofilm Engineering
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Iwona Beech
Microbiology & Plant Biology
Organic Microbiology

Jennifer Brown
Chemical & Biological Engineering
Rheology and biofilm mechanics

Anne Camper
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James Wilking
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Tianyu Zhang
Mathematical Sciences
Mathematical modeling

RESEARCH

Fiscal 2017's slate of new federal funding research grant support tallied $3.1 million. Research topics of these awards ranged from understanding the roles of bacteria in microbial communities, to using microfluidics to develop virus-fighting therapies, to eradicating biofilms in metal working fluids.

$3.1 MILLION IN RESEARCH GRANTS

PRIMARY AREAS OF RESEARCH

- Biofilm control strategies
- Energy solutions
- Environmental technologies
- Health/medical biofilms
- Industrial systems and processes
- Standardized methods
- Water systems

More on CBE research areas at: http://www.biofilm.montana.edu/research-program/index.html

Ross Carlson awarded US Army Research Office Grant for chronic wound treatment

[Excerpt taken from an article written by Jodi Hausen, MSU News Service]

A Montana State University professor has received funding from the US Department of Defense to further his research on the role different species of bacteria play in microbial communities. The research has the potential to impact society by creating new strategies for fuel production and improving outcomes for wounded soldiers.

Ross Carlson, professor of chemical and biological engineering, received the three-year, $655,000 grant from the US Army Research Office.

In collaboration with Michael Henson, chemical engineering professor at the University of Massachusetts, Carlson hopes to discover the role various bacteria play within their microbial community and how they organize themselves within a biofilm to achieve those goals.

"If we can understand how these bacterial communities naturally organize spatially, we can use that fundamental understanding to enhance the function of good microbial communities and counter the activity of bad ones," Carlson said.

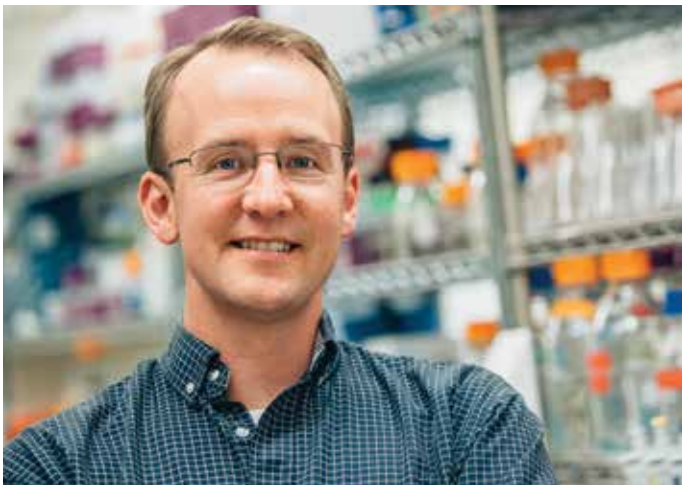


Photo courtesy of Adrian Sanchez-Gonzalez of MSU News
Ross Carlson

The research suggests the two bacterial species—*Staphylococcus aureus* and *Pseudomonas aeruginosa*—operate in a complementary and synergistic manner. The waste compounds from one metabolism are used as a food for another metabolism, enhancing the overall productivity of the community and complicating the treatment of chronic wound infections. The researchers are now testing the predictions with experiments to quantify the behaviors and to validate and refine computer predictions of the synergistic interactions.

Non-healing chronic wounds affect an estimated 2 percent of the US population—about 6 million people—with treatment costing more than $25 billion a year, the paper states.

A better understanding of the makeup and functioning of chronic-wound biofilm bacteria could potentially lead to new treatments to counteract this effect and promote healing in wounds for soldiers and others who suffer from chronic wounds.

A better understanding of the makeup and functioning of chronic-wound biofilm bacteria could potentially lead to new treatments to counteract this effect and promote healing in wounds for soldiers and others who suffer from chronic wounds.

Jeff Heys, head of MSU's Department of Chemical and Biological Engineering, said Carlson's research represents the next generation of research in bioprocess engineering and control of medical infections.

"It is only by understanding the interactions within communities of microorganisms that we can help the Army to produce sustainable biofuels or help doctors to eliminate persistent infections," Heys said.

Jim Wilking's lab uses 3D printing to create customized biofilms

In recent years, 3D printing has become a popular topic. It is being used in a wide range of scientific fields including electronics, automotive, aerospace, and medical engineering. Now a team of Montana State University researchers is attempting to build customized biofilms using 3D printing technologies.

Jim Wilking, assistant professor in chemical and biological engineering, and his team of students are learning to build their own biofilms by using 3D printers. These printers will allow Wilking and his team to control the composition of a biofilm by layering the microbes in various ways.

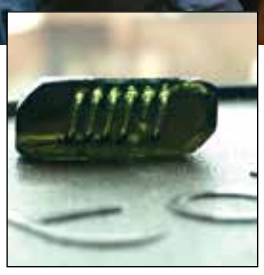
"We are interested in designing biofilms using 3D printing in the same way that bioengineers have been structuring artificial tissue," Wilking said. "There is a lot of potential for structuring biofilms in a well-controlled way."

The process suspends microbes in a liquid resin. When the resin is exposed to laser light in the 3D printer, it is crosslinked from a liquid to a soft, but solid, hydrogel. These bioprints can be layered to create three-dimensional customized biofilms.

"By controlling exquisitely the stratification and density of the microbes in a biofilm, you can understand relationships in these systems and that allows you to optimize a bioproduct," Wilking said. "We are really trying to engineer biofilms with new, efficient properties to produce bioplastics, high-value products, fuels, and potentially even electricity."

Above: Photo courtesy of Adrian Sanchez-Gonzalez of MSU News

Jim Wilking (left) and Aaron Benjamin watch a "biofilm" being created on a 3D printer.



Right: Photo courtesy of Aaron Benjamin, undergraduate student at MSU

This hydrogel cube, created by Aaron Benjamin using a 3D printer, is the consistency of Jell-O and contains internal channels for transporting liquids in and out of the cube.

50 PUBLICATIONS

PEER-REVIEWED JOURNALS

PUBLICATIONS IN:

- Algal Research
- American J Infection Control
- AMB Express
- Analytical Chemistry
- Annals of Biomedical Engineering
- Antimicrobial Agents and Chemotherapy
- APMIS
- Applied Microbiology Biotechnology
- Astrobiology
- Biofouling
- Biometals
- Bioresource Technology
- BMC System Biology
- British Journal of Dermatology
- Chemical Engineering Science
- Chemical Geology
- Colombia Médica
- Drug Design Development and Therapy
- Ecological Engineering
- Energy Procedia
- Environmental Microbiology
- Environmental Science & Technology
- Environmental Technololgy
- Environmental Science: Water Research & Technology
- Expert Review of Anti-infective Therapy
- Genome Announcements
- Intl J Coal Geology
- J Bacteriology
- J Occupational Environmental Medicine
- J Wound Care
- Nature Methods
- Nature Geoscience
- npj Biofilms and Microbiomes
- PLoS One
- PNAS: Proceedings of the National Academy of Sciences
- Scientific Reports
- Science of the Total Environment
- Transport in Porous Media
- Water Research
- Water Resources Research
- Wound Repair & Regeneration

Connie Chang receives $1.3 million to develop virus-fighting technology

[Excerpt taken from an article written by Marshall Swearingen, MSU News Service]

Photo courtesy of Adrian Sanchez-Gonzalez of MSU News

Connie Chang

A Montana State University researcher and her colleagues have received a $5.2 million grant to push the boundaries of a new approach for treating flu and other fast-evolving viruses that resist traditional vaccines.

Connie Chang, assistant professor in the Department of Chemical and Biological Engineering in MSU's College of Engineering, received $1.3 million of the funding, which was awarded by the Defense Advanced Research Projects Agency, an independent agency of the US Department of Defense that funds "high-risk, high-reward" projects.

Chang and her team are exploring the use of a sophisticated method called drop-based microfluidics for producing therapeutic interfering particles, or TIPs, for treating influenza. "Once we understand how this applies to flu, we could potentially use this method to make TIPs for other viruses," Chang said. DARPA lists more than 40 "high priority viral pathogens," including Ebola, HIV, and Zika, as candidates for treatment using TIPs.

TIPs are stripped-down, harmless versions of viruses. While traditional vaccines consist of a weakened or killed virus that prompts the body's immune system to produce antibodies, TIPs are engineered to hijack a harmful virus's reproduction process, creating more TIPs while reducing the ability of the virus to spread and cause illness. TIPs are thought to have several potential advantages over vaccines, including an ability to co-evolve with the harmful virus and remain effective for longer periods.

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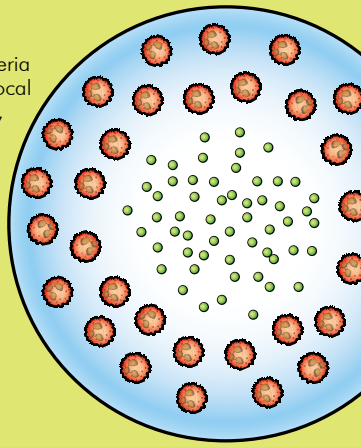
Chang, whose Soft Matter and Microfluidics Lab is part of MSU's Center for Biofilm Engineering, played a major role in developing microfluidics as a tool for virology with funding from another DARPA grant as a postdoctoral scholar at Harvard University, before coming to MSU in 2013 and taking a tenure-track position in 2015.

"These are challenging concepts," Chang said. "We're aiming for something that could seem impossible. But with DARPA, they want you to try these high-risk, high-reward projects."



An aggregate of bacteria (green) depletes the local oxygen concentration, reducing the effectiveness of attacking neutrophils (red). One strategy to boost neutrophil efficacy may be to increase oxygen levels, keeping neutrophils healthy and ready for action.

Neutrophils vs. Biofilms

Phil Stewart

Phil Stewart, professor of chemical and biological engineering, is breaking new ground understanding the inner workings of biofilms.

"I'm interested in what we can learn from the process the body uses to fight infections, primarily the process in which white blood cells destroy them," Stewart said. "I'm convinced that the answer to the problem of medical-device infections lies in unveiling why, in the case of biofilms, white blood cells don't suceed as they usually do." Answering that question could lead to the engineering of medical devices that direct white blood cells to more effectively destroy the bacteria that form biofilms.

Stewart, and graduate student Brian Pettygrove, simulate a newly implanted medical device in which a few contaminating bacteria are pitted against isolated human neutrophils, a type of white blood cell. If the bacteria evade clearance and establish a biofilm, an infection will result. If the host defenses clear the biofilm, an infection will be prevented. Can we learn to guide the host defenses to prevent infections on medical devices? This could be a powerful alternative to the current strategy of painting antimicrobial agents, such as silver, onto medical implants.

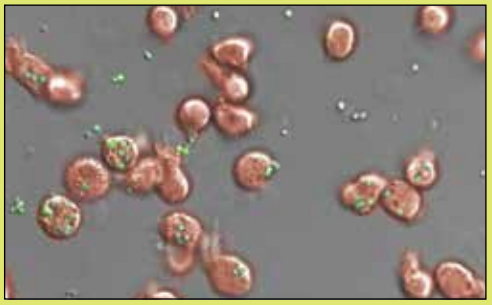


Photo courtesy of Betsey Pitts and Phil Stewart

This image tracks neutrophils (red) as they discover and destroy bacteria (green) on a biomaterial surface.

EDUCATION

Graduate and undergraduate students work under the guidance of the CBE's multidisciplinary faculty to solve problems associated with biofilms in medical, industrial, and environmental settings.

200+ MASTERS & DOCTORAL DEGREES AWARDED*

* since 1990

700+ UNDERGRAD PARTICIPANTS*

GRADUATE PROGRAM

More than 200 masters and doctoral students have earned their degrees in the CBE's graduate research program since the CBE was founded in 1990. CBE graduate students acquire valuable experience by designing and performing research that crosses traditional academic discipline boundaries and has direct impact on current environmental, industrial, and medical issues. In addition, the CBE's Industrial Associates program brings students into working relationships with potential employers. CBE graduate students are encouraged to develop their communication and leadership skills by presenting at research conferences, mentoring undergraduate students, organizing the CBE's seminar series, and assisting with outreach efforts. The CBE's standing as a leader in the international research community attracts visiting students and faculty from all parts of the world, providing a culturally diverse and stimulating academic environment. Graduate students pursue their degree in a discipline offered through one of the science, agriculture, or engineering departments at Montana State University while conducting research in CBE laboratories.

For more information, go to:
www.biofilm.montana.edu/educational-experience/graduate.html

UNDERGRADUATE PROGRAM

More than 700 undergraduate students have worked on biofilm research at the CBE since 1990. Undergraduate students are highly valued team members in the MSU Center for Biofilm Engineering and are fully integrated into the research process. Our undergraduates learn to design and implement experiments that will provide results relevant to industry and the science community—and they develop the skills that will broaden their career opportunities and make them more valuable to prospective employers. For undergraduates who decide to pursue graduate degrees, their CBE research experience is often cited as a key component in being selected by their program of choice.

For more information, go to:
www.biofilm.montana.edu/educational-experience/undergraduate.html

Students gain experience giving seminars and leading workshops

Students are encouraged to share their research with peers and industry representatives during the Montana Biofilm Meeting. They gain valuable leadership skills while giving seminars, leading workshops, and interacting with colleagues from across the country and abroad.

Grace Dickerman, undergraduate, chemical and biological engineering, leads a demonstration during the 2017 Montana Biofilm Meeting workshop.

Photo courtesy of Adrian Sanchez-Gonzalez of MSU News

Barkan Sidar, PhD candidate, chemical and biological engineering, explains a poster at the CBE's open house during the 2016 Montana Biofilm Meeting.

Isaac Miller receives NSF Graduate Research Fellowship to study fish and algae

[Excerpt taken from an article written by Evelyn Boswell, MSU News Service]

Isaac Miller doesn't just enjoy fishing Montana's rivers and trout streams, he also likes to study the microbial communities that surround and inhabit those fish.

Miller has worked for two years at the Bozeman Fish Technology Center while studying ecology at Montana State University. He is currently a research technician in MSU's Center for Biofilm Engineering. And now, Miller has received a prestigious fellowship that will allow him to build on that background while earning his PhD in microbiology.

Miller is one of MSU's 2017 recipients of a Graduate Research Fellowship from the National Science Foundation. The fellowship will give Miller $34,000 a year for three years to investigate, among other topics, the bacteria, viruses, and other microorganisms that live inside the gastrointestinal tracts of fish.

Learning more about the complex microbial communities that live in fish, the fish microbiome as it's called, can help scientists understand how fish digest food and use their nutrients. That knowledge can help in the management of fish nutrition and growth, lead to the discovery of unique natural products and provide basic knowledge that lays the foundation for future research projects applied to water and food needs for society.

Among other things, Miller and his collaborators at the CBE and Bozeman Fish Technology Center will grow algae from fish wastewater, turn the algae into fish food, feed the food to fish, and compare the algal-fed fish with fish on other diets.

Matthew Fields, director of the CBE and head of the laboratory where Miller works, said, "Some of the major challenges that society faces today include clean water, food, and energy, and we are interested in developing solutions for water and nutrient recycling with algal and microbial biofilms. We want to find ways to re-use water and waste products to produce valuable products (food and energy), by consuming sunlight and atmospheric carbon dioxide."

Miller credits both Fields and postdoctoral researcher Heidi Smith for their roles in his success. Smith, in particular, encouraged Miller to apply for the NSF fellowship. "This program is an amazing opportunity for students to get experience in grant writing and obtaining their own funding to study a project of their choice," Smith said. "After working with Isaac for only a few months, it was obvious that he had an incredibly strong and tireless work ethic. He also possesses a genuine curiosity for science and learning."

The National Science Foundation selected this year's 2,000 recipients of the Graduate Research Fellowship from a pool of more than 13,000 applicants. According to the NSF, the Graduate Research Fellowship Program is critical in the agency's overall strategy to develop a globally engaged workforce necessary to ensure the nation's leadership in advancing science and engineering.

This program is an amazing opportunity for students to get experience in grant writing and obtaining their own funding to study a project of their choice.

—Heidi Smith

Photo courtesy of Adrian Sanchez-Gonzalez of MSU News

Isaac Miller

Image courtesy of Isaac Miller

This unicellular green algae is an isolate from coal bed methane pond water. Miller plans to test this algae as a bioremediation tool for the removal of excess nutrients such as nitrate and ammonia from fish wastewater.

CBE undergrads present at the National Conferences on Undergraduate Research

Five MSU-CBE undergraduate students presented their research at the 31st annual National Conferences on Undergraduate Research, held in April at the University of Memphis in Tennessee. Brooke Filanoski, Emily Hultin, Taylor Oeschger, Rita Park, and Hanna Showers were among 13 MSU students who traveled to Tennessee to present their work. Hultin, Oeschger, and Showers each delivered a 20-minute oral presentation of their work, and Filanoski and Park presented posters of their research during the conference poster sessions. Their presentation titles are listed below:

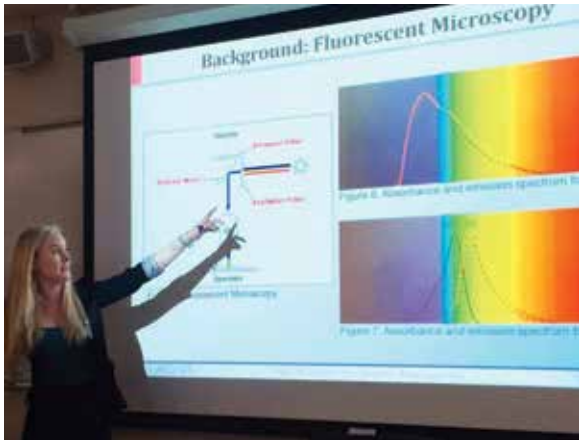


Photo courtesy of Kevin Jones
Taylor Oeschger

Brooke Filanoski, chemical and biological engineering, "Microbial induced calcium carbonate precipitation of coal combustion residuals" (poster)

Emily Hultin, chemical and biological engineering, "Characterization of Antarctic algae for biofuel potential" (oral presentation)

Taylor Oeschger, chemical and biological engineering, "Application of laser etching and 3D printed polymers for modeling ice vein habitats" (oral presentation)

Rita Park, microbiology & immunology, "Effect of coal particle size on microbial methanogenesis in the presence of oxygen" (poster)

Hanna Showers, chemical and biological engineering, "Rheological and atomic force microscopy investigation of carotenoid pigmented Antarctic heterotrophic bacteria" (oral presentation)

To read about all of the researchers and the conference, go to MSU News: "MSU students present projects at national conference that promotes undergraduate research"

EQUALITY IN EDUCATION

62 UNDERGRADUATE STUDENTS

29 Women • 33 Men

52 GRADUATE STUDENTS

28 Women • 24 Men

DEPARTMENTS

UNDERGRADUATE STUDENTS

7 Departments

- Chemical & Biological Engineering
- Chemistry & Biochemistry
- Civil Engineering
- Land Resources & Environmental Sciences
- Mechanical & Industrial Engineering
- Microbiology & Immunology
- Modern Languages & Literature

GRADUATE STUDENTS

8 Departments

- Chemical & Biological Engineering
- Chemistry & Biochemistry
- Civil Engineering
- Health & Human Development
- Land Resources & Environmental Sciences
- Material Sciences
- Microbiology & Immunology
- Nursing

STUDENT SPOTLIGHT

3-Minute Thesis Competition

For the past three years, MSU has hosted an event for graduate students to share their highly technical projects, giving the public a chance to hear an 80,000-word thesis distilled into 180 seconds. The event is a competition called 3-Minute Thesis and MSU hosted the event in March 2017 at the Procrastinator Theater on campus.

The seven finalists chosen for the 3-Minute Thesis competition are from disciplines across MSU's College of Engineering. The finalists explained, very concisely, how their research might affect the public. Presenters were required to condense their research into a brief, engaging presentation for a non-specialist audience, using a single presentation slide.

For the past three years, the winners have been CBE students:

2017 Drew Norton, masters student, Civil Engineering

2016 Jeffrey Simkins, PhD student, Chemical & Biological Engineering

2015 Catherine Kirkland, PhD student, Civil Engineering

Photo courtesy of Adrian Sanchez-Gonzalez of MSU News

Drew Norton, masters student, civil engineering, presents his research at the CBE's 2016 Montana Biofilm Meeting.

New 'prodrugs' may fight biofilms from within

Danica Walsh

Danica Walsh, a PhD student working at the Center for Biofilm Engineering, is developing antimicrobial agents to combat biofilm-forming bacteria in industrial, hospital, and household settings. Walsh works in the laboratories of Tom Livinghouse, professor of chemistry and biochemistry; and Phil Stewart, professor of chemical and biological engineering.

What are you currently working on?

We're creating new chemical compounds to serve as biocide prodrugs—modified antimicrobials designed to infiltrate and destroy detrimental biofilms. Structurally, these new compounds are similar to the Calcein AM dyes we use to illuminate biofilm cells under the microscope. We are finding ways to attach antimicrobial agents to these compounds to combat biofilms from within their cells.

What is a "prodrug?"

A prodrug is a compound that is inactive until it is chemically altered. In this case, once our compound is in the cell, it's acted upon by esterase enzymes and becomes trapped. This is an excellent method for drug delivery and retention.

What is your role in this advancement?

I am synthesizing an array of prodrug-style antimicrobial compounds, as well as testing them for efficacy against bacterial cells. I'm also measuring their activities when exposed to esterase.

Why is this important?

The majority of microorganisms that occur in nature—including those that drive the corrosion of metals, contaminate water resources, cause infectious wounds, and foul industrial processing equipment—live in association with surfaces as biofilms. These biofilms are difficult to control with antimicrobials, which may fail to permeate the robust extracellular matrix and the cell membrane. The goal of this project is to synthesize several antimicrobial prodrugs to control a diverse array of bacteria that form biofilms.

INDUSTRY

The CBE keeps its research relevant by maintainting a dynamic industry membership program. We engage with industry across a wide spectrum of markets, including specialty chemicals, consumer products, healthcare, and testing services.

INDUSTRIAL MEMBERSHIP—EVERYONE BENEFITS

The Industrial Associate Membership Program benefits our students by bringing them into working relationships with potential employers. Our faculty and researchers have the opportunity to work on projects that are industrially relevant. As full participating members, companies enjoy these benefits:

- Access to new research and CBE investigators
- Invitations to specialized workshops
- Exclusive invitations to CBE's Montana Biofilm Meeting and regulatory meeting in Washington, DC
- Opportunities to interact with other companies, as collaboators and as suppliers
- Two days of individualized/custom consultation per year by CBE researchers
- Opportunities for sponsored research, beyond the pooled research program, to address specific concerns
- Access to students in biofilm research for permanent hire and for internships
- Early access to CBE publications
- Access to state-of-the-art tools for biofilm analyses

2016–2017 INDUSTRIAL ASSOCIATES

3M • Accuratus Lab Services* • Acelity • American Chemet* • BASF / Ciba Specialty Chemicals • Baxter Healthcare, Inc. • Church & Dwight Co., Inc. • CleanSpot, Inc.* • DeLaval • Dow Microbial Control • Ecolab • ICU Medical, Inc. • Lonza • Masco Corporation • NASA • NCH Corporation • Next Science* • PPG Industries • Procter & Gamble Co. • S.C. Johnson & Son, Inc. • SANUWAVE Health* • Sharklet Technologies, Inc.* • Smith & Nephew • Solvay • Sterilex* • STERIS • The Sherwin-Williams Co. • W.L. Gore & Associates • Zimmer Biomet

* small business member ■ new member

Expert panel advises aggressive initial treatment for patients with chronic wounds

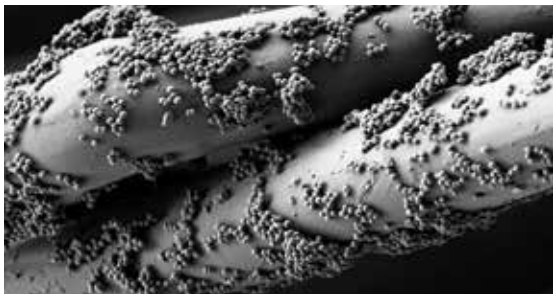
Garth James, manager of the CBE's Medical Biofilms Laboratory, participated in an international biofilm expert panel that included leading researchers from Australia, Denmark, Japan, United Kingdom, and the United States. Convened by CBE industrial member Smith & Nephew, a major medical manufacturing company based in London, the Global Wound Biofilm Expert Panel recently called for physicians around the world to reverse the longstanding practice of gradually escalating treatment of patients with chronic wounds.

Garth James

"We are recommending physicians change course and start treating chronic wounds very aggressively initially," James says. "This is the exact opposite of traditional wound-care practice where you try something minimally invasive then get increasingly aggressive as needed."

The recommendation for the new treatment protocol appears in the cover story of January 2018 online edition of *Wound Repair and Regeneration* titled "Consensus guidelines for the identification and treatment of biofilms in chronic nonhealing wounds."

In 2017, the expert panel published an article titled, "The prevalence of biofilms in chronic wounds: a systematic review and meta-analysis of published data," in the January 2017 edition of the *Journal of Wound Care*.



This image shows a wound dressing with associated bacterial cells.

Image courtesy of Kelly Kirker

Partnerships lead to new industry standards and better tasting beer

[Excerpt taken from an article written by Marshall Swearingen, MSU News Service]

In Darla Goeres' lab, the beer on tap is Sierra Nevada Pale Ale. But when it comes out of the keg with a frosty head, it's not for drinking. Instead, Goeres and her collaborators at the Standard Biofilm Methods Laboratory use the brew to study how to improve the taste of beer by finding new ways to remove taste-altering biofilms from the plastic lines that carry beer from keg to tap.

Photo courtesy of Adrian Sanchez-Gonzalez of MSU News

Darla Goeres (left) and Lindsey Lorenz prepare to test a beer draught line for biofilm buildup.

"When you get a beer and have a sip and think 'that doesn't taste right,' it's probably because of biofilm," said Goeres, an associate research professor in the Department of Chemical and Biological Engineering in MSU's College of Engineering. The biofilm forms when harmless bacteria, brewing yeast and other residual solids, form a coating on the inside of draught lines.

Currently, the Boulder, Colorado-based Brewers Association recommends that beer distributors clean draught lines biweekly by flushing them with disinfectant and water, Goeres said. But knowing how often to clean the lines, and judging the results, can be a challenge. "(The brewing community) wants actual data to support their recommendations and ultimately to improve the cleaning regimen," she said. "The goal is to provide their customers with the highest quality beer possible."

It's an example of the industry partnership that the Center for Biofilm Engineering is well known for.

To study the biofilm, Goeres and her team partnered with local beer distributors to construct a laboratory system that mimics the draught systems commonly found in bars, complete with long sections of tubing. The researchers then added specific strains of bacteria—those that commonly cause the beer biofilm to form—into the draught lines coming out of the keg of pale ale, which was donated by Sierra Nevada Brewing Company. In a bar or brewery setting, the bacteria are introduced when couplers or other equipment aren't totally clean when switching out kegs or tap handles, Goeres said.

Goeres' research is funded by the Brewers Association, and is being conducted in partnership with NSF International, an organization specializing in the development of public health standards and certification programs. It's an example of the industry partnership that the Center for Biofilm Engineering is well known for.

Within a year, Goeres and her team hope to publish their results, which could inform the development of new products or processes for cleaning draught lines.

"We're able to take something that's more complex than most people realize, bring it into the lab to understand what's going on, and develop tools so that companies can come up with solutions," she said.

2016/2017 MEETINGS

Montana Biofilm Science & Technology Meeting

July 19–21, 2016 Bozeman, MT

4th Annual Regulatory Pathways Meeting

February 1, 2017 Washington, DC

Montana Biofilm Science & Technology Meeting

July 18–20, 2017 Bozeman, MT

UPCOMING 2018 MEETINGS

5th Annual Regulatory Pathways Meeting

February 6–7, 2018 Washington, DC

Montana Biofilm Science & Technology Meeting

July 17–19, 2018 Bozeman, MT

$640,370 TESTING PROJECTS*

66 PROJECTS

30 SPONSORS

* FY 2017

OUTREACH

While undergraduate and graduate programs are the CBE's primary education focus, CBE faculty, staff, and students disseminate biofilm information to people outside the Center in a number of ways.

Online training videos

The CBE's Standardized Biofilm Methods Lab has spent the last year developing and producing a series of videos for the world to watch and learn from. These videos teach methods for repeatable biofilm growth and sampling techniques, and offer the visualization of some of these standardized techniques. The latest of these videos is the Drip Flow Biofilm Reactor Training Video. Find this and other videos at:

www.biofilm.montana.edu/standardized-biofilm-methods-training-videos.html

VISITING RESEARCHERS

The CBE is an international hub for biofilm research, education, and technology transfer. It attracts students, scientists, and faculty from all over the country and around the world.

Kristina Block, visiting masters student, Berlin Technological University

Marta Bottagisio, visiting PhD student, University of Milan, Italy

Greg Characklis, visiting faculty, University of North Carolina, Chapel Hill

Sepideh Ebadi, visiting PhD student, Florida State University

Marketa Hulkova, visiting PhD student (Fulbright), Masaryk University, Brno, Czech Republic

Birthe Kjellerup, visiting faculty, University of Maryland

Maria Clara Tarifa, visiting PhD student, Universidad Nacional Del Sur, Buenos Aires, Argentina

James Vallie, visiting undergraduate student, Little Bighorn College, Hardin, Montana

Top: James Vallie, visiting undergraduate student, presents his research at a 2016 poster session

Bottom: Marta Bottagisio (back row, second from the left) with the CBE medical biofilms staff

CBE joins the AMiCI Action Network

The number of infections caused by multi-drug resistant bacteria continues to increase at a significant rate. A potential and promising weapon against bacterial growth and possibly the development of multi-drug resistant bacteria has been found in antimicrobial nano-coatings. These coatings are fortified with an active ingredient that can eliminate growth of the microorganisms. The organization behind this development is the Anti-Microbial Coating Innovations (AMiCI) Action Network, a European cooperation of science and technology leaders. In 2017, the CBE became an official international collaborator, joining about 20 countries. This partnership will facilitate further research into antimicrobial coatings and potential healthcare uses to prevent infectious diseases.

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