Quarterly Newsletter
Fall 2021

SD EPSCoR UPDATE

Linking South Dakota's Future with STEM Research

Features

DESIGNING 3D BIOPRINTING SOFTWARE

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ALSO IN THIS ISSUE

SD EPSCoR is funded by the National Science Foundation under the current award #OIA-1849206. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the view of the National Science Foundation.

SD EPSCoR
RESEARCH. EDUCATION. ECONOMIC DEVELOPMENT.

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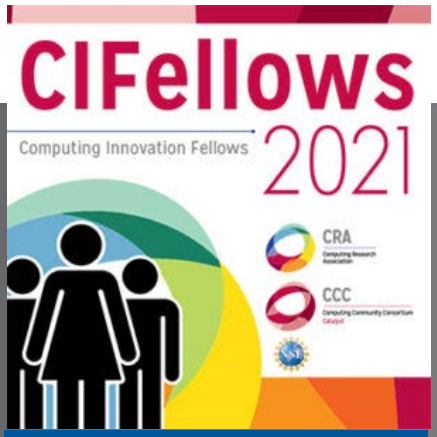
AT LEFT

Tim Hartman holds one of the ring-shaped items 3D-printed as part of the research and testing in the biomedical engineering program at USD. More on pp. 3-5.

ON THE COVER

Dr. Etienne Gnimpieba and Tim Hartman examine a collection of structures they've 3D-printed, including graphene structures and miniature scaffolds. See pp. 3-5.



10-11

Designing Data-Driven Bioprinting Software for the Biotech Industry

Images and Text By Jenifer Fjelstad, SD EPSCoR Intern and Augustana University senior

Bioinformatics and 3D bioprinting are revolutionizing the worldwide biomedical device industry. Here in South Dakota, USD researchers are engineering intuitive automation software to speed the bioprinting processes, thanks to funding by the National Science Foundation.

Tim Hartman peered at his laptop to examine 500 image pairs, sets of control and test versions. He logged data from the research from the past 20 years into his team's image analysis software, Bioinformatics Analysis, Statistic, and Image Comparison (BASIN).

As the senior biomedical engineering undergraduate student adds new code into his program, the software learns to analyze the photos of microscopic structures. The soon-to-be-published research will be part of a larger network of data-mining software that aims to automate a portion of 3D biomedical lab work.

"I think bioprinting has a lot of potential," Hartman said.

The research on data-driven bioprinting software, under the faculty direction of his professor, Dr. Etienne Gnimpieba, is funded by a Track-1 grant from the National Science Foundation to South Dakota EPSCoR. Hartman conducts the engineering research, titled "Data-Driven Bioprinting for Biomedical Applications," along with his team at the GEAR Center at the USD Community College for Sioux Falls campus.

"It will impact the research community and the biotechnology industry if we get something relevant," Gnimpieba said. "When I say it will impact the biotechnology industry, that means it will impact the patient. We are trying to get as close to the patient as possible."

Once it's all set, the software will speed the process of developing new biocompatible materials and devices — that have a makeup fitting with living organisms. This causes a more efficient process for experiments involving 3D bioprinting and, ultimately, the production of biomedical devices for human health.

It's foremost an engineering project, Gnimpieba said. At the beginning, Hartman checked the feasibility and reviewed the available literature, and now, he is bridging between computation and the lab aspects of the project.

Hartman said this is his first time being the first author on a project, and his role has focused on the BASIN image analysis software and getting familiar with the 3D printer.

The images in BASIN, the tool that analyzes these images objectively, were derived from part of the Track-1 project, Biofilms Knowledge and Information Discovery System (Biofilm-KIDS).

Hartman presented this research at SD EPSCoR's virtual Undergraduate Research Symposium in July. He said poster sessions are important because they allow him to share his research with those outside his field to get an "external, unbiased take" on his work.

Hartman also presented this research in the Capitol Rotunda alongside 15 other students from various universities at the annual spring Student Research Poster Session, organized by South Dakota EPSCoR and the South Dakota Board of Regents, at the state capitol in Pierre.

"Getting to present some of his work to this conference helps him to have a different perspective on how he analyzes the problem and develop a new solution," Gnimpieba said. "It's always very helpful, especially for a young researcher." Hartman said he enjoyed connecting others with his research at the event by making it relatable on a personal level and simplifying the jargon.

NEW FACULTY HIRES

Dr. Alexey Lipatov, South Dakota Mines, Assistant Professor for Chemistry Biology and Health Sciences (CBHS) — and Chemical and Biological Engineering (CBE).

Over his career, Lipatov got experience in materials science and nanotechnology by working on the synthesis and characterization of low-dimensional materials and utilizing them for applications in electronics, memory devices and sensors. At South Dakota Mines, he will develop a research program on the synthesis and characterization of two-dimensional materials with the focus on rational design of large-scale, cost-efficient 2D coatings for applications in electronics and sensors. Lipatov earned his bachelor's and master's degrees at Lomonosov Moscow State University (Russia) and his doctorate at the University of Nebraska-Lincoln.

Dr. Saurabh Dhiman, South Dakota Mines, Assistant Professor for both Chemistry Biology and Health Sciences (CBHS) — and Civil and Environmental Engineering (CEE).

Hired at South Dakota Mines as a postdoc in 2015, Dhiman earned both his master's and doctoral degrees at Kurukshetra University (India), and is working on SD EPSCoR's NSF Track-1 project (2019-24).

Dhiman is part of the team awarded a $6 million NSF grant and $1.8 million SD Governor's Office of Economic Development grant in 2017 to study the range of novel extremophiles for biotransformation of next generation of carbon feedstocks.

His research, however, is anything but simple.

The compound software will use the thousands of articles and up to 100 structural designs available for 3D bioprinters. It will save significant time for scientists by not only finding relevant articles but also optimizing them, which creates a protocol of the best structure and materials for the experiment. The users will simply review the findings and connect the digital blueprint with their 3D bioprinter.

"You'd just put your chemical into the printer, upload the 3D structure file, and then 'go,'" Hartman said. "And you could make a hundred of them, a thousand of them at one time if you wanted to. It's automation; it's just a different type of automation."

The compound software will use the thousands of articles and up to 100 structural designs available for 3D bioprinters.

The data-driven research breaks down into an image analysis tool, an article conversion tool, a storage system for high-quality original images and a biovisualizer. Their idea is cyclical: As other scientists use the system to do their research, they'll add the new research back into the system for it to become more up-to-date and dynamic.

Hartman's focus right now is creating software, but he said he hopes to work more with hardware, like the 3D printers, in his future career. "As long as [it's] a tangible product that moves science forward, as long as I help make that, then I'm okay doing software development," Hartman said.

Hartman spent last summer familiarizing himself with the versatile 3D bioprinter in the GEAR Center. He practiced carefully squeezing the syringe to draw in the printing liquid, loading it smoothly into the extruder, and uploading and connecting the digital files. The machine does the rest as air pressure pushes the stopper to release the ink-substance onto the build-plate following the design to create the final product.

Originally from Sioux Falls, Hartman graduates in 2022 and, then, plans to pursue a doctorate in biomedical engineering. Before beginning school for his STEM degree, he worked with submarine nuclear propulsion in the Navy and then with cabinetry hardware. Studying bioinformatics has been one step along the way to his goal of working with biomedical devices. "This has helped me continue on my career path of hardware development with a flavor of software development," Hartman said.

His current project is focused on a specific subsection of medical research called bioprinting. Most people are familiar with 3D printing, which funnels plastic into a 3D form based on a digital blueprint. Bioprinting, similarly, takes the computer's instructions and creates a form — that could fit compatibly inside a human body. Hartman said the new and rapidly emerging area of scientific study supposes that because the body is 3D, so should be the medical devices that help heal it.

"That's the goal — to get to the point where you can just insert a scaffold, and your body's cells will grow on the scaffold and, then eventually, dissolve the scaffold. And now you've got as good as new," Hartman said.

New Communications Intern

Jenifer (Jeni) Fjelstad is a senior studying journalism and French at Augustana University (AU). As an editor with AU's Mirror newspaper, she works to share stories and to cover important events, each with accuracy and compassion. Fjelstad supports SD EPSCoR by assisting with website content and social media.

Graduate Student Spotlight: Elisha Yellow Thunder

The area of interest for Elisha's graduate research is located on the ancestral territories of the Oglala Lakota – Oceti Sakowin, located within the Ft. Laramie 1851 & 1868 treaty boundaries of the Wazi Ahanhan Oyanke (Pine Ridge Indian Reservation) in South Dakota.

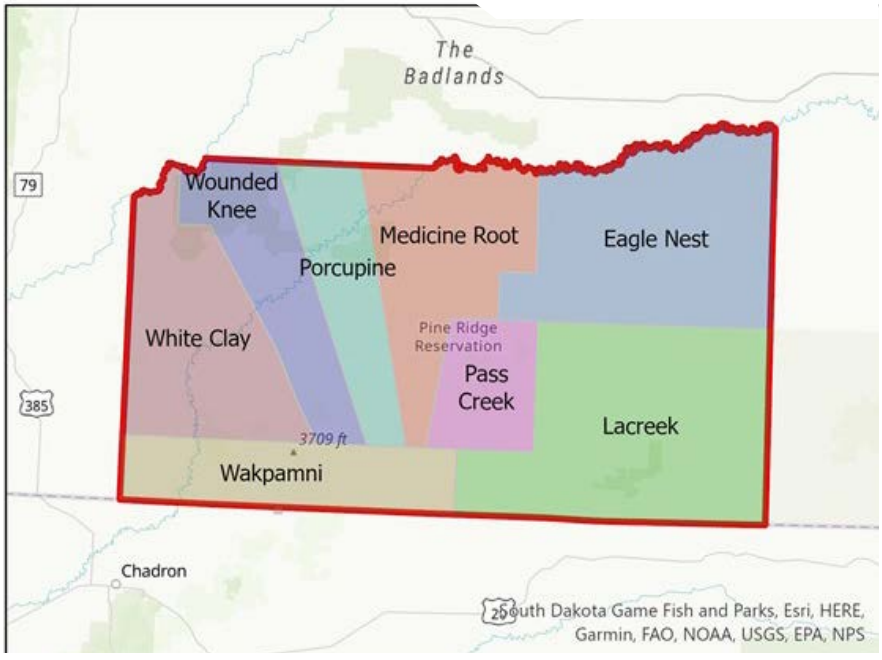
Text By Hailey Nold, spring/summer SD EPSCoR intern and Augustana University alumna

When her first-born was diagnosed with kidney failure and received the first of two transplants at age 9, Elisha Yellow Thunder wondered if her diagnosis had to do with the water quality near their home. Due to these experiences and the potential impact of this research on her community, Yellow Thunder felt determined to study the risk assessment of arsenic mobilized nitrates in the Arikaree aquifer on the Pine Ridge Reservation.

Her hypothesis is that nitrates are becoming mobile in the water due to the arsenic found in the geological formations. With the arsenic mobilized nitrates being carcinogenic, she feels it is worthwhile to look at the rangelands and formations and understand the potential correlations.

In 2019, Yellow Thunder was a senior at Oglala Lakota College (OLC) in Kyle, South Dakota, when Dana Gehring, a faculty member at OLC, encouraged her to pursue a graduate degree. She applied and was accepted to South Dakota State University (SDSU), where she now studies natural resource management.

She said her research has benefitted from EPSCoR in almost too many ways to count. With the NSF EPSCoR Track-1 project providing financial support, Yellow Thunder was able to pursue her graduate degree along with a research assistantship.



Swift Bird et al. (2021) discovered that in certain regions of the Arikaree aquifer the arsenic and uranium occurring in local geological formations are mobilized by iron hydroxides, nitrates, and sulfates.

Objectives:

1. Develop a risk assessment model of vulnerabilities in the Arikaree Aquifer using MODFLOW (usgs.gov), a modular hydrologic model.
2. Database engineering for the Oglala Sioux Tribe.

“[Without EPSCoR], I don’t think I would be where I am today … living a life I never thought was possible growing up. I cannot express how much EPSCoR has helped me to achieve my dreams. I am forever grateful to EPSCoR and my OLC mentors.”

— Elisha Yellow Thunder, Graduate Researcher

Everything Yellow Thunder does is in pursuit of a better way of life for her community on the reservation. She hopes to implement effective research in Indigenous communities and create a research environment that is conducive to the needs and wants of her tribe’s community members and elders. For Yellow Thunder, it is vital that her community keeps and supports scientific research so that she can develop strategies that alleviate the suffering she has experienced and observed.

She continues to give back to her community through mentorship, as well. Upon graduating with her bachelor’s degree from OLC in May 2020, she assisted with the Summer Institute for area high school students. This summer, Yellow Thunder is directing a team of Summer Institute students in collecting water samples that she will analyze for her research. She is also educating them on research methods and encouraging the continuation of their education. Upon graduating with her master’s degree from SDSU, Yellow Thunder hopes to return to the Pine Ridge Reservation and teach at OLC.

When she isn’t collecting data or empowering the next generation, Yellow Thunder finds herself rediscovering her culture. She is returning to dancing at Wacipi (powwow), spending time beading her moccasins and jewelry, and sewing her dress.

STATEMENT IN RECOGNITION OF TRIBAL DATA SOVEREIGNTY

It is held throughout the research project that tribal data sovereignty takes precedent over any key stakeholder data interests. The data gathered by the graduate researcher will be taken in accordance with tribal rules and regulations with complete recognition of cultural and spiritual sampling methodology. It is imperative that the researcher develop a close working relationship with local community members, Tribal Council members, respected elders, spiritual leaders, knowledge keepers, and water and earth protectors. This working relationship is vital to both the Indigenous communities in the areas of interest and the researcher. Through this relationship the researcher can learn and respect the traditional methods of sample extraction. This knowledge will validate the researcher to the Indigenous community and will create an open space for data and results dissemination.

2D Best Track-1 Seed Grant Awards

Text By
Jenifer Fjelstad, SD EPSCoR Intern and Augustana University senior

The second year's seed grants were awarded for high-risk, high-reward biofilm research at the intersection of biofilms, 2D materials and big data. Four seed grants (up to $50,000 each) are awarded annually.

A brief description of each Year-2 Seed Grant follows:

Quantifying biofilm growth impacts on performance of wastewater infiltration systems modified with 2D materials

Dr. Stu Geza at South Dakota Mines (SDSMT) studies bioclogging, which occurs when biofilms plug the pore space in soil, impacting wastewater and stormwater infiltration systems. Geza is investigating how 2D materials, like graphene oxide, could modify soil to block bioclogging and achieve a better-working water infiltration system.

The research results may prevent problems like septic tank failure and stormwater backup. The goal is to analyze the modification's effects on water infiltration rates, or the time water takes to sink into underground reservoirs, and the environmental effects of graphene oxide in that system.

Geza plans to pursue funding from the Department of Defense (DoD), the Environmental Protection Agency (EPA) and the United States Department of Agriculture (USDA) to support future research.

Plasma jet coating for biofilm applications

Dr. Prasoon Diwaker at SDSMT is testing a coating technique applying 2D materials to metals and non-metals to guard from biofilms. The materials with these coatings applied could resist harmful biocorrosion, a wearing-away of certain materials by the organisms in biofilms.

The goal is to produce a cost-effective and defect-free method that can be scaled up to fit industrial applications. For example, the technique could be applied across pipeline projects, the health industry, agriculture and package manufacturing.

If successful, further funding will be pursued through the DoD, the National Science Foundation (NSF) and the USDA.

Are you receiving the weekly grant announcements and biweekly Digest? Complete the form at sdepscor.org/listserv to receive timely news and information.

Synthetic nodules using polysaccharide beads for sustainable plant nitrogen nutrition

Dr. Srinivas Janaswamy at SDSU investigates sustainable nitrogen nutrition for cereal crops. He is studying synthetic beads as a nitrogen-fixing method to partially supplement typical nitrogen-rich fertilizer.

It could mean a more environmentally friendly alternative for farmers of corn and wheat because the beads are suspected not to be subject to as much leaching into groundwater. The biodegradable beads would provide a consistent source of nitrogen-fixation, a process to pull nitrogen from the environment and convert it to a useable form by plants to aid in their growth.

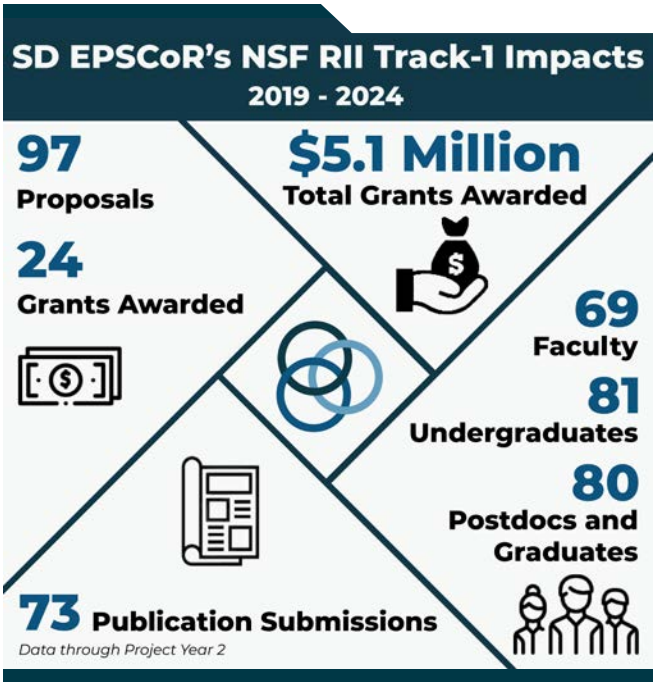
Opportunities to fund this project in the future may come from the USDA and NSF.

Role of priority effect on gut microbiota assembly on gut mucosal interface

Dr. Abhijit Maji at SDSU studies the interaction of gut microbiomes and bacterial biofilm. The types of colonization on the mucus of the gut barrier impact diseases and a level of overall health. Formation of a biofilm with mostly beneficial bacteria could mean better gut health.

Maji studies the "priority effect," that says order and timing of bacteria growth matters. He hypothesizes that early adhesion of beneficial bacteria would attract other beneficial types.

The research could lead to probiotics and bacterial treatment to improve gut health in humans and animals. Maji plans to seek further funding from the National Institute of Health (NIH), USDA and the DoD.



Project Year in Review: NSF EPSCoR Research Within South Dakota

SD EPSCoR will complete Year 2 of its NSF RII Track-1 Project in September 2021 with 69 faculty, 81 undergraduate students, and 80 postdocs and graduate students participating. Project participants submitted 97 proposals and received 24 awards, totaling $5.1 million. Research results have been described in 73 articles submitted for publication.

Image by
Jenifer Fjelstad, SD EPSCoR Intern & Augustana student

CIFellows 2021

Computing Innovation Fellows

Vincent Peta Chosen as 2021 CIFellow

The CIFellows program, which is funded by the Computing Research Association and the Computing Community Consortium, was created in response to the COVID-19 pandemic, to assist recent Ph.D. graduates facing unexpected challenges in securing research positions. Previously, the CIFellows program was open for applications between 2009 and 2011 when the economy was in a recession.

Dr. Vincent Peta, a postdoctoral fellow at the University of South Dakota (USD) Sanford School of Medicine, was awarded a spot in the highly selective National Science Foundation's Computing Innovation Fellows (CIFellows) program, designed to help recent Ph.D. graduates continue research despite COVID-19.

Peta is the first from South Dakota to be awarded this fellowship. In 2021, about 240 people applied to the CIFellows program, and 69 were accepted into the 2021 class.

Dr. Etienne Gnimpieba, in collaboration with Dr. Jose Pietri, will mentor Peta in the program at the USD Sanford School of Medicine. According to Gnimpieba, an SD EPSCoR Track-1 researcher, "This fellowship is a wonderful opportunity that emphasizes the need to bridge computing and bioengineering."

Research Title: Prediction of Protein Structure and Function to Identify Novel Mechanisms of Resistance to Vector-Borne Pathogens in Insects

Research Description: The aim is to leverage a machine-learning framework to develop a systems biology predictive tool with a custom data mining workflow that will be tailored to protein structure prediction. The overall goal is to try to see how immune system-related proteins from insect vectors could impact the possible infection of these insect vectors and spread of microbial pathogens in the environment and to humans.

Mentor: Etienne Gnimpieba, Assistant Professor of Research at USD

Although mainly involved in the NSF Track-2 project, Peta has also helped with the SD EPSCoR NSF Track-1 project, helping run the first version of the bioinformatics workflow for SRB (sulfate-reducing bacteria) pangenome data analysis in collaboration with Dr. Rajesh Sani's lab at South Dakota School of Mines and Technology (on the XSEDE high-performance computing cluster). This is part of the bioinformatics goal and data management task in Track-1 (to populate the Biofilm-KIDS system with biofilm organism genomic information), and Track-2 (to add new dataset for machine learning model development).

This pangenome task is playing a key role with the 2021 IEEE CBEAS (Computational Biofilm Engineering and Application) international workshop where Peta will be working on the organization.

"The current CIFellows project will be very useful to both projects because the protein structure modeling is a core bioscience issue with large applications," Gnimpieba added.

Originally from Mitchell, South Dakota, Peta started his undergraduate degree at South Dakota State University (SDSU) in fall 2010 majoring in microbiology and graduated in fall 2014. He also earned his doctorate in microbiology in 2020 from SDSU, and worked with Indigo Ag and Novozymes North America during his doctoral program as part of the SDSU lab's industry collaborations. He enjoys the outdoors and trying out new cooking recipes.

The current NSF Track-1 project, "Beyond the 2020 Vision: Building Research, Education and Innovation Partnerships for South Dakota," is found at *sdepscor.org/2DBest*.

How did you decide to apply for this award?
"We thought it would be an opportunity for me to get more experience in grant writing and, also, potentially in the areas of data science and computational biology, which are areas I do venture in, but still don't have a lot of experience in. Being from a biology background, we do use computers in our daily work, and we are seeing a huge movement of biology into a more computational form with huge amounts of data driving projects and collaborations between different labs and areas of research. This is huge when you think of all the ways the data must be looked at and processed — and no one person or lab can do it all. It makes you think of all the possibilities one could achieve when you bring two different areas like this together."

What do you hope to gain from the experience?
"I really am excited about this opportunity, not just from a research perspective but also from a learning perspective. Having the opportunity to work with researchers in both areas and learn how to build and operate a lab — as well as learn new techniques and getting to meet people I otherwise would not have met — I think, is simply amazing."

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Sept. 23, Sioux Falls and Online
sdepscor.org/talent

Economic Outlook Seminar
Oct. 5, Sioux Falls Convention Center
sdchamber.biz

South Dakota Innovation Expo
Oct. 7, Sioux Falls (Hilton Garden Inn)
Oct. 14, Rapid City (Ascent Innovation)
sdinnovationexpo.com

S.D. FAST Launch Business Bootcamps
Nov. 6 & Dec. 4; Online, 8:30 a.m.–4 p.m. CT
sdepscor.org/sdfast