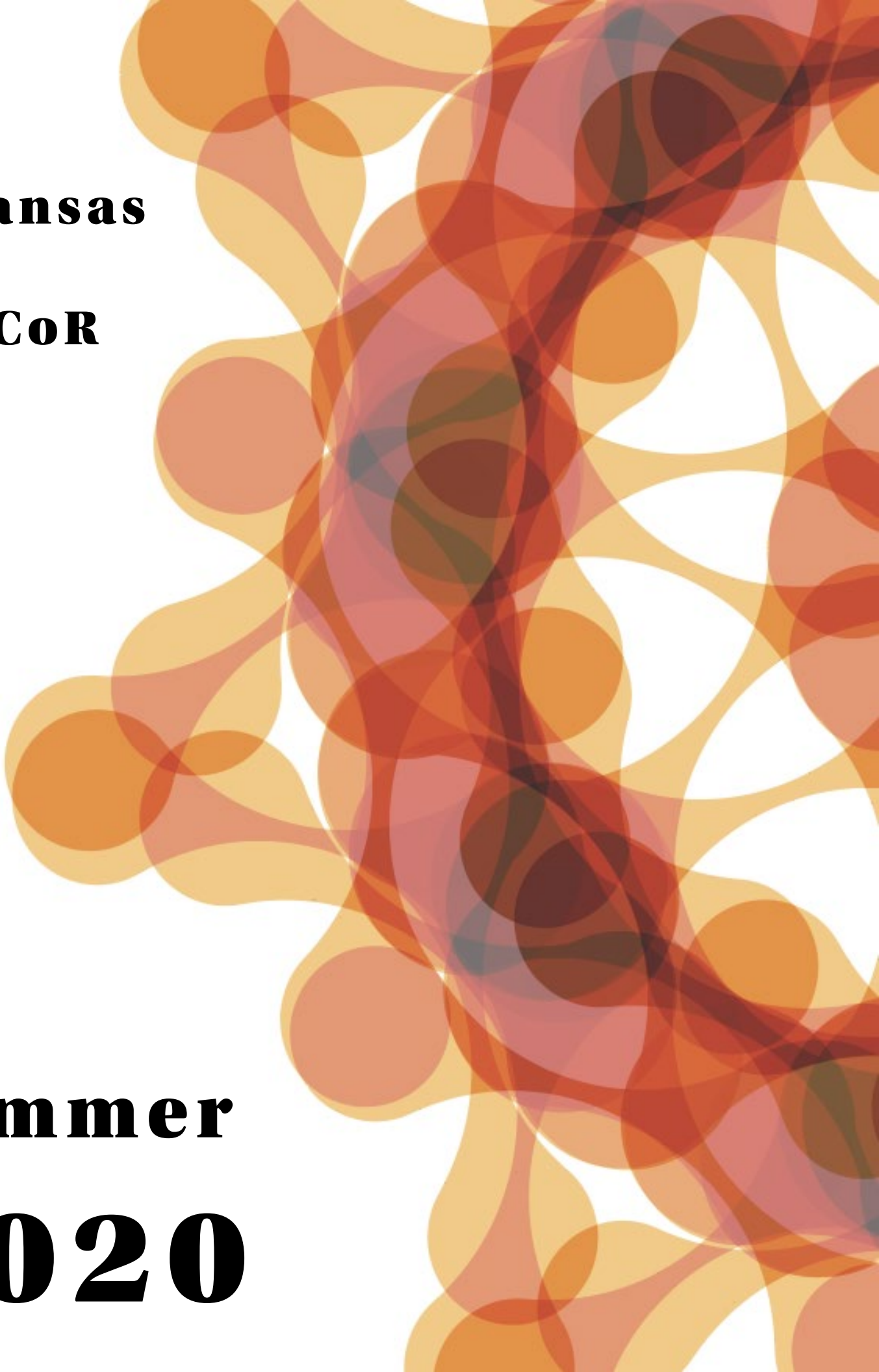
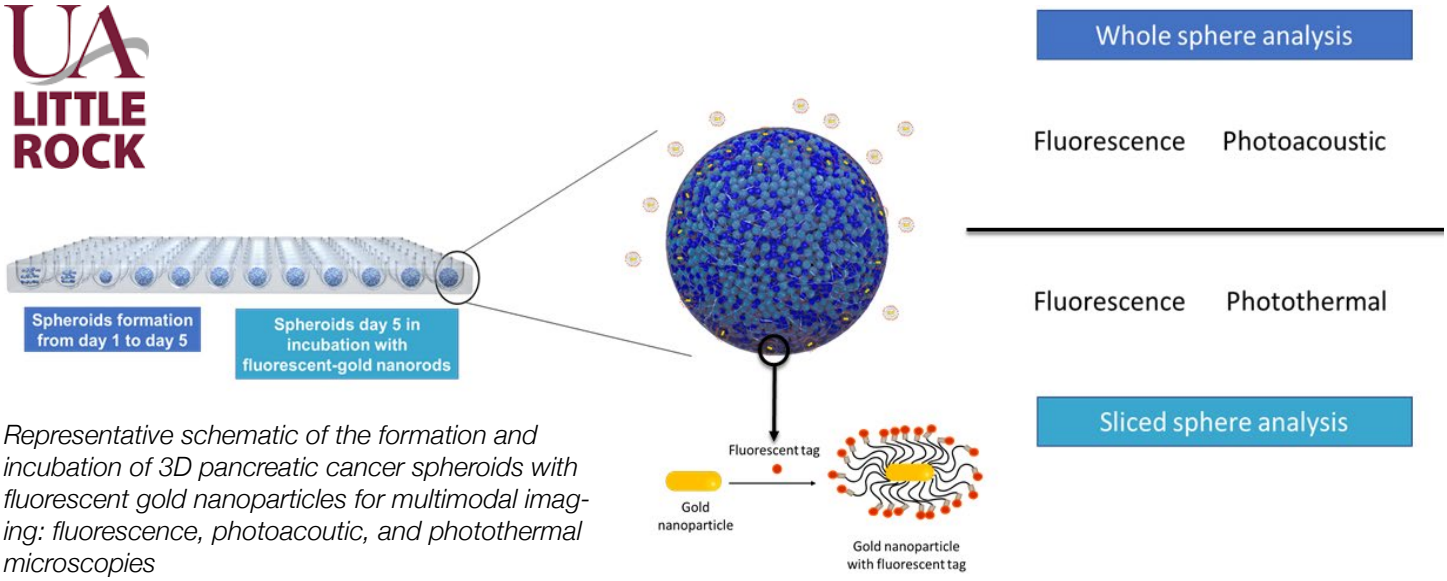
Arkansas NSF EPSCoR



Summer 2020

IN THIS ISSUE

Arkansas Researchers Investigate Nanomaterials for Possible Applications in Cancer Treatment



Representative schematic of the formation and incubation of 3D pancreatic cancer spheroids with fluorescent gold nanoparticles for multimodal imaging: fluorescence, photoacoutic, and photothermal microscopies

A team of researchers including Dr. Emilie Darrigues and her advisor Dr. Alexandru S. Biris have developed pancreatic cancer multicellular 3D spheroids by co-culturing cancer cells and stellate cells, to mimic real in vivo tumor-stromal compositions. This model allowed them to investigate the interaction and penetration of plasmonic gold nanorods in a realistic environment using multimodal analytic techniques—fluorescence imaging, photothermal, and photoacoustic microscopies.

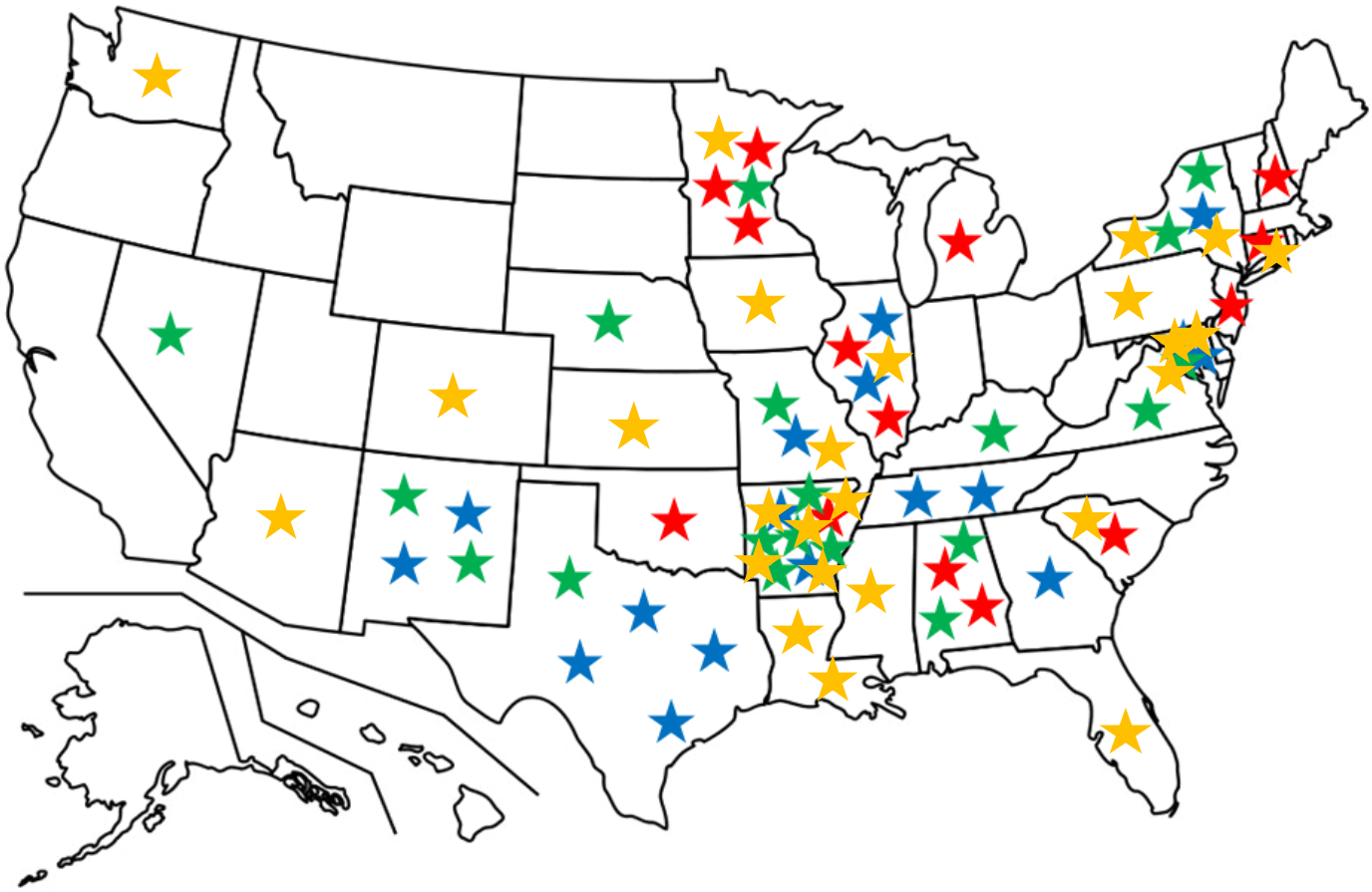
Determining how tunable plasmonic nanoparticles interact with a 3D cancer model that mimics real tumor features can help improve pancreatic cancer therapies by enabling the in vitro optimization of therapeutic nanoparticle functionalization. Additionally, enabling multimodal imaging techniques in 3D cultures may support diagnosis and imaging abilities.

The development of nanosystems for cancer therapy has been hampered by the limitations of current in vitro models, generally two-dimensional (2D) models that struggle to provide an accurate representation of the in vivo environment. 3D culture models and spheroids have been shown to simulate in vivo features much more accurately, including the dynamic tumor microenvironment. Additionally, evaluation of nanoparticles' interaction with spheroids to estimate their penetration and diffusion abilities has mainly be done by using fluorescence tracking. Few other techniques have been applied in spheroids; however, this method can provide inaccurate results.

With the support of the NSF EPSCoR program, as well as UA Little Rock and UAMS, the team utilized the unique, intrinsic photoacoustic and photothermal contrast signals of gold nanoparticles to identify them in the spheroids without relying only on fluorescence, which enabled multi-imaging analysis and confirmed that tracked fluorescence signals might not always be related to the nanoparticle.

An Update from the AR-CURE Project

OUACHITA BAPTIST UNIVERSITY



The Arkansas Course-embedded Undergraduate Research Experience (AR-CURE) Project is a training program hosted at Ouachita Baptist University, funded by AR NSF EPSCoR, and led by Dr. Nathan Reyna. The main goal of the program is to train faculty from primarily undergraduate institutions how to incorporate real research in their classrooms, especially if they have little or no access to science laboratories and equipment.

While many academic research programs involve a small number of upper-level students each semester, the incorporation of research into the classroom setting expands the number of students involved in experimental research, benefiting a larger number of diverse students and potentially increasing scholastic rigor across entire academic programs.

The first faculty workshop was held in 2017 on the OBU campus and 17 faculty from 16 campuses (blue stars above) around the country attended. In 2018, the second AR-CURE hosted 17 faculty from 15 institutions (red stars) and in 2019 it was expanded to 25 faculty participants from 19 institutions (green stars). The nature of this training is very interactive, and when the pandemic started in 2020, the team was unsure how to proceed if not in-person. Dr. Reyna took the event virtual and in 2020 AR-CURE trained 28 faculty from 25 campuses online (gold stars).

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There is growing national recognition of the need to reform undergraduate biology education in ways that allow all students to be engaged in the genomics revolution that is reshaping biological research. A major barrier is the lack of resources and opportunities for faculty training and professional development in genomics methods such as synthetic biology and bioinformatics. This is especially true at historically black colleges and universities (HBCUs), tribal colleges and universities (TCUs), Hispanic-serving institutions (HSIs) and community colleges (CCs), with the consequence that these minority-serving institutions (MSIs) cannot engage in needed curriculum reforms designed to reflect the genomics revolution.

Feedback from the workshop has been incredibly positive, and AR-CURE has led to some other great outcomes. In 2019, an AR-CURE Genome Hack-a-thon was hosted at OBU where around 25 high school students participated on teams led by OBU undergraduates to piece together the genome of a virus. A second event was scheduled for March of 2020 with approximately 90 students but was postponed due to the pandemic.

The AR-CURE team also has built 13 STEM kits for high school classrooms that walk students through a hands-on polymerase chain reaction experiment. These kits were issued to the University of Arkansas at Fort Smith and a couple of regional educational service cooperatives. Two teacher professional development workshops have been held.

28 faculty participated in the 2020 Virtual AR-CURE through Zoom

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After the first couple of AR-CURE faculty workshops, Dr. Reyna and colleagues submitted a proposal to NSF under the Research Collaborative Network in Undergraduate Biology Education (RCN-UBE) program to fund a national network of faculty doing cell culture-based research in undergraduate classrooms. That proposal was awarded and in 2018, the Cell Biology Education Consortium (CBEC) was founded with a five year award. CBEC has grown to over 151 registered faculty members and over 400 students participating in the United States.

While isolated groups are introducing cell culture techniques into such experiences, there had been no coordinated effort to compile resources and provide training that makes creating customizable cell-culture-based research projects easier to implement at smaller, primarily undergraduate institutions and community colleges where faculty time and resources are limited. CBEC addresses these major shortfalls through the creation of a network of faculty, students, and resources that will provide an infrastructure to facilitate the development and implementation of unique student-driven research experiences. By creating projects that align with a curriculum's learning goals and desired student outcomes, these activities will help strengthen critical thinking skills in and beyond the classroom.

The primary activity of CBEC is the development of "Cell Blocks," modules consisting of written and video protocols and classroom implementation strategies and assessments. Cell Blocks are developed by faculty and their students at small institutions making it likely that they will be adaptable at similar schools. The modules can be mixed and matched to answer novel research questions, which serve as the basis for semester-long research projects that provide the foundation for independent student research projects. CBEC faculty have opportunities for professional development through the creation of new Cell Blocks, access to all Cell Block modules and associated supplies, and networking opportunities. Student participants interact within a community of scientists to expand on their experiences and create their own independent research projects, establish a funding record through a voucher system, and participate in professional development experiences.

The CBEC YouTube page has over 100 subscribers, and the original Cell Block protocol video that was made by undergraduates at Ouachita Baptist University has over 25,000 views. Another popular protocol video has about 2,300 views. So far, CBEC has produced 18 videos that demonstrate different techniques and protocols in cell biology tissue culture.

We look forward to seeing more amazing results from the AR-CURE and CBEC. To stay informed, check out the websites and social media channels linked below. Dr. Reyna can be reached at reynan@obu.edu.

CBEC

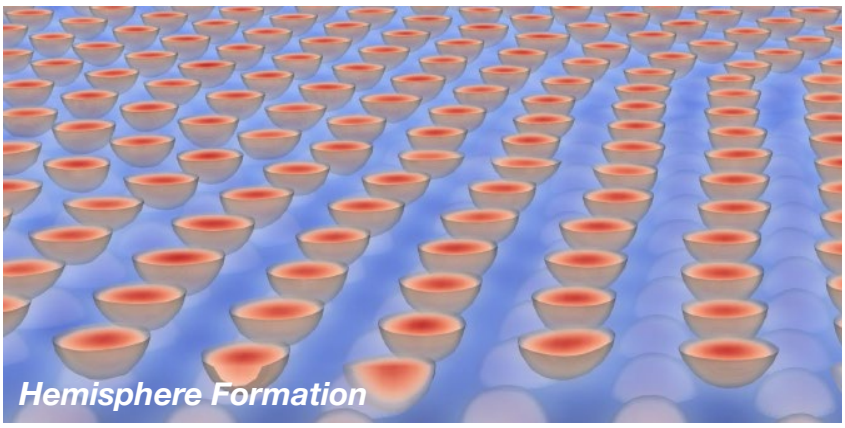
www.cellbioed.com

YouTube

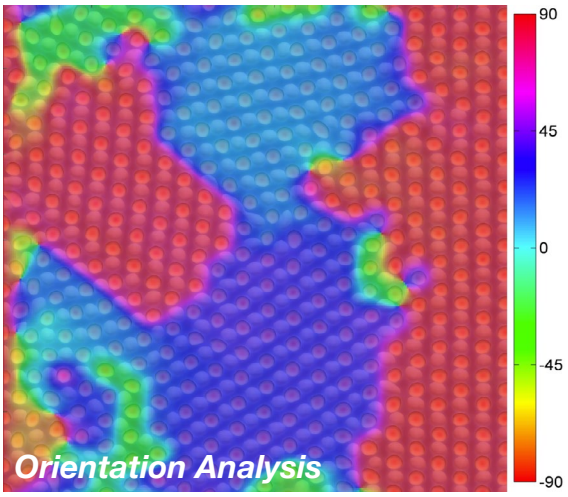
AR CURE

Improving Photolithography Manufacturing Processes with Diblock Copolymers

UNIVERSITY OF ARKANSAS



Three dimensional view of a phase separated, sphere-forming, PS-b-PMMA block-copolymer system. The minority polymer forms hemispheres on the uper and lower substrates. The majority polymer has been rendered transparent to show upper and lower pattern formations.



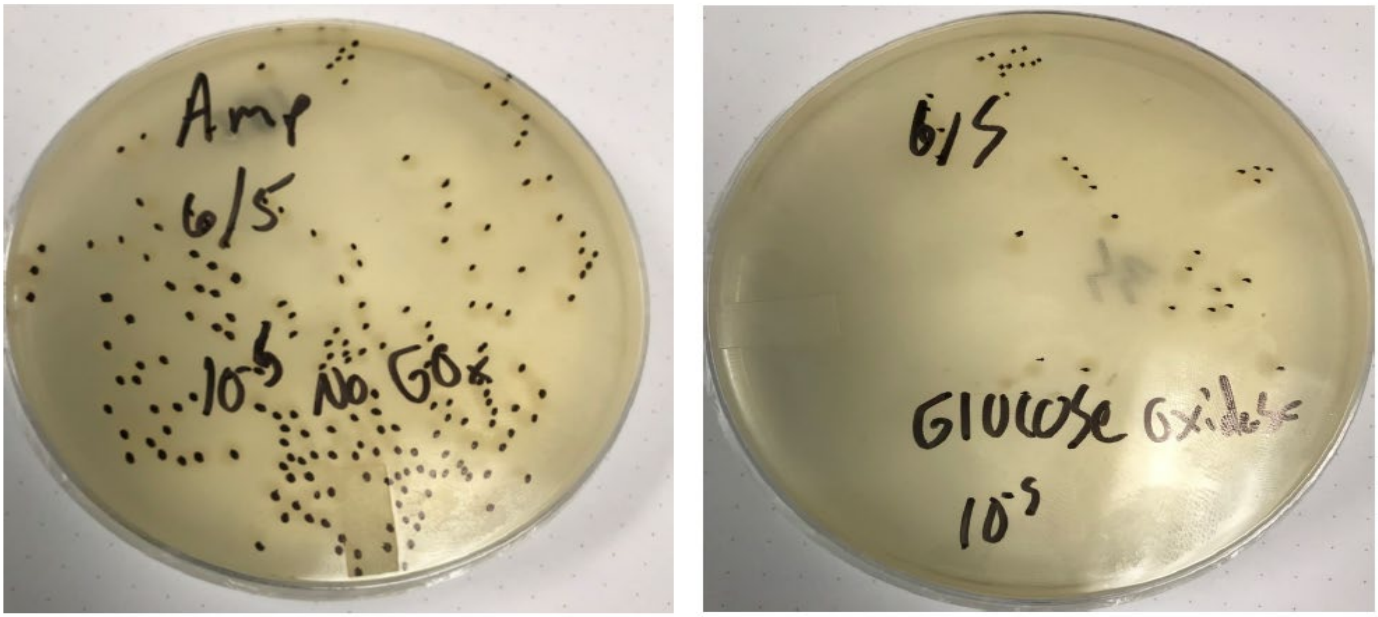
Top down view of the same block-copolymer system. Hemispheres attached to the upper and lower surface form regular patterns. Color overlay represents local orientation in the surface pattern.

PhD student Joseph Hill and advisor Dr. Paul Millett are working to improve current photolithography techniques in manufacturing by developing new thin films with special structures at nanoscale. If researchers can develop special thin films that have patterns at nanoscale, the current photolithography processes that are used in manufacturing microprocessors, hard drives, and semiconductors could be improved by several factors.

Polymers are long molecular chains of material like Styrofoam, and a copolymer is two polymers blended together. Block copolymers are bonded at the molecular level. Because block copolymers are molecularly linked, the separation can only happen at nanoscale. Rather than separating like oil and water when heated, they separate into regularly patterned structures depending on the ratio of the two components, like layers. For example, think about a three-dimensional block that is made up of spheres of polymer type A inside a large pool of polymer type B. When you apply this as a thin film on a surface, you get hemispheres that attach to surface. They naturally form in a disorganized method, but techniques could be applied to create an ordered pattern on the film. The researchers are investigating how to make that a single uniform pattern with no defects.

The main application of this technology is photolithography, which is how semiconductors, microprocessors, and memory storage drives are manufactured. In traditional photolithography, the resulting image size is limited because of the size of the light particles. In the example of memory storage or magnetic media, information is stored on individual dots on a surface. If researchers can increase the density of the dots, the storage capacity would be increased. With the new technology described, the density could be increased from 100 dots in a 30-nanometer area to 100 dots in a 5-nanometer area.

Engineering a New Antimicrobial Material



Antimicrobial effects of 0.01% w/v GOx. Ampicillin resistant *E. coli* were treated with PBS (left) or GOx (right) and plated (after 10^5 dilution). Individual colonies were marked black using a marker pen.

A team of researchers including Dr. Shanzhi Wang at University of Arkansas Little Rock have shown that enzyme glucose oxidase (GOx) has excellent antimicrobial effects when used in solution or conjugated on membranes. Determining the antimicrobial effects of GOx can serve many purposes, especially medically as a disinfectant or antiseptics on skin.

We currently have a good understanding of the antimicrobial mechanism of GOx: producing H2O2 which is toxic to a verity of microbials. However, H2O2 can also be toxic to tissues because of its oxidizing power. It became of the reasons that the enzyme was not well characterized for its antimicrobial potentials.

The team reasoned that GOx is only active in presence of glucose, and glucose (in serum) could activate GOx to kill bacteria. This is the case for skin wounds, where serum become available and microbials are often accumulated. As such, bandage containing GOx could disinfect the skin wounds without attacking intact skin, and the antimicrobial effects will stop when the skin wound is closed (e.g. by coagulation).

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