Project Notes:

Project Title: Designing a Robot to Measure Soil Hydrophobicity and Optimize Tilling for Hydration
Name: Venkayala, Sanvi

Knowledge Gaps:

This list provides a brief overview of the major knowledge gaps for this project, how they were resolved and where to find the information.

Knowledge Gap	Resolved By	Information is located	Date resolved
How can antibacterial activity be evaluated?	Reading an article on CuO coated prosthetic liners and their antimicrobial evaluation	Article #5 in project notes	09/10/25
What are all the properties of BC in more detail?	Reading an article on the production & characterization of BC	Article #7 in project notes	09/19/25
How can BC be integrated with fabric?	Reading an article on fabric-complexed material with BC	Article #8 in project notes	09/20/25
What are different ways to integrate antimicrobial properties into BC?	Reading multiple articles where this was done	Article #5 & #6 & #11 in project notes	10/01/25
How does tillage affect soil/is it important to distinguish between hydrophobic and non-hydorphobic soils?	Reading articles and looking at graphs that compare tillage vs no-tillage	Grant Proposal Introduction section	10/27/25
What types of methods are used to measure soil hydrophobicity?	Read articles about soil hydrophobicity	Articles 15, 16, 18	11/08/25
What types of models for WDPT/CA automated measurements are already out there?	Read articles about other models	Article 17 & 19	11/15/25

Literature Search Parameters:

These searches were performed between (08/20/2025) and 01/16/2025.
List of keywords and databases used during this project.

Database/search engine	Keywords	Summary of search
Google	Journal articles on piezoelectric wound dressings	Found article-->Mechanical contraction and electrical stimulation improve wound healing times
Google	Bacterial cellulose prosthetic liners	Found article-->An antibacterial evaluation of different prosthetic liner textiles coated by CuO nanoparticles
Google	Information about WDPT and CA tests	Found article describing the test
WPI Gordon Library	Tillage systems effect on soil	No results popped up
Google Scholar	Tilling for post-wildfire soils	No results
Google	Simulating hydrophobic soil	Found an article detailing the use of paraffin wax for simulation
Google	Preparing videos for ML model	Found an article detailing some steps for labeling videos for ML models
Google	Current models for temporal-based analysis	Article about ActionFormer, a model that detects actions in time
Google	ML models that are the best for video/image analysis	Found article about CNNs being used in image analysis

Article #0 Notes: Template

Article notes should be on separate sheets

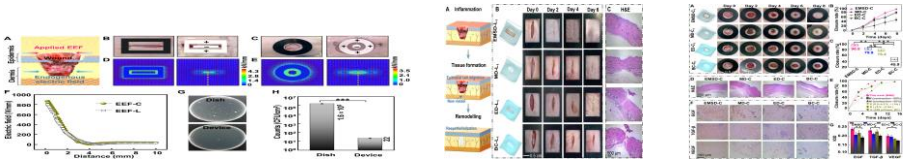
KEEP THIS BLANK AND USE AS A TEMPLATE

Source Title	
Source citation (APA Format)	
Original URL	
Source type	
Keywords	
#Tags	
Summary of key points + notes (include methodology)	
Research Question/Problem/ Need	
Important Figures	
VOCAB: (w/definition)	
Cited references to follow up on	
Follow up Questions	

Article #1 Notes: A programmable and skin temperature–activated electromechanical synergistic dressing for effective wound healing

Source Title	Science.org/ ScienceAdvances
Source citation (APA Format)	Yao, G., Mo, X., Yin, C., Lou, W., Wang, Q., Huang, S., Mao, L., Chen, S., Zhao, K., Pan, T., Huang, L., & Lin, Y. (2022). A programmable and skin temperature–activated electromechanical synergistic dressing for effective wound healing. *Science Advances*, *8*(4). https://doi.org/10.1126/sciadv.abl8379
Original URL	https://www.science.org/doi/10.1126/sciadv.abl8379
Source type	Research Article
Keywords	Mechanical contraction, Electrical stimulation, Electromechanical synergistic wound dressing, Shape memory alloy, Antibacterial electret thin film

Summary of key points + notes (include methodology)	There has not been much research addressing the use of contraction on wounds, the customization of dressings for different-shaped wounds, and the effect of an electromechanical wound dressing. To solve this, researchers developed a flexible, battery-free device that combines mechanical contraction through the use of shape memory alloy grids with patterned electrical fields. Their electromechanical synergistic device (EMSD) resulted in faster healing in both linear and circular wounds in rats, demonstrating its effect on wound therapy.
	Methodology: They tested their wearable on linear and circular wounds on rats by having 4 test groups. One group was for the mechanical dressing (MD), one for electrical dressing (ED), one for the whole device (EMSD), and one blank control (BC) group with no wearable. For linear wound healing, by day 6, it was found that the ESMD group had complete reepithelization and remodeling unlike other groups. For circular wound healing, the ESMD group had the highest percent of wound closure by day 8 (96.8%).
	
	The Design:
	
	EMSD integrates:
	
	• Shape Memory alloy grids for contraction of material
	• Patterned Electric Field electrodes for electrical stimulation
	  ○ Generated uniform electrical fields that could penetrate up to 10mm into tissue
	  ○ 99.99% antibacterial efficacy against E.coli
	• It is skin-temp regulated and uses body heat to trigger mechanical contraction

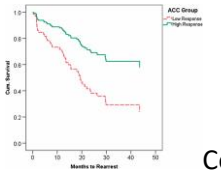
	Mechanical Contraction (MD): The SMA grids deform to close the wound • There are 2 types: one for linear wounds and one for circular wounds Electrical Simulation: EEFs enhance endogenous electric fields that allow for cell migration, tissue regeneration, and antibacterial activity Linear Wound Healing • ESMD-L: complete reepithelialization and remodeling by day 6 • MD-L & ED-L: incomplete healing • BC-L: epidermis not regenerated Circular Wound Healing • EMSD-C: 96.8% closure by day 8 • MD-C: 79.9% • ED-C: 76.4% • BC-C: 45.9%
Research Question/Problem/ Need	Can combining mechanical contraction and electrical stimulation improve a wound's healing process better compared to using one of those methods alone?
Important Figures	
VOCAB: (w/definition)	Dehisce: gape or burst open H&E staining: Hematoxylin and Eosin, a staining technique, that uses 2 dyes to color cell nuclei blue and cytoplasm pink, allowing tissue structure examination Endogenous: having an internal cause or origin
Cited references to follow up on	Y. Long, H. Wei, J. Li, G. Yao, B. Yu, D. Ni, A. L. F. Gibson, X. Lan, Y. Jiang, W. Cai, X. Wang, Effective wound healing enabled by discrete alternative electric fields from wearable nanogenerators. ACS Nano 12, 12533–12540 (2018). S. Du, N. Zhou, Y. Gao, G. Xie, H. Du, H. Jiang, L. Zhang, J. Tao, J. Zhu, Bioinspired hybrid patches with self-adhesive hydrogel and piezoelectric nanogenerator for promoting skin wound healing. Nano Res. 13, 2525–2533 (2020).
Follow up Questions	• If the contraction timing could be adjusted depending on the stages of healing, could the wound's healing process be quickened? • Can this device be used for other injuries such as muscle injuries?

Article #2 Notes: Neuroprediction of future rearrest

Source Title	Pnas.org
Source citation (APA Format)	Aharoni, E., Vincent, G. M., Harenski, C. L., Calhoun, V. D., Sinnott-Armstrong, W., Gazzaniga, M. S., & Kiehl, K. A. (2013). Neuroprediction of future rearrest. *Proceedings of the National Academy of Sciences*, *110*(15), 6223–6228. https://doi.org/10.1073/pnas.1219302110
Original URL	https://www.pnas.org/doi/full/10.1073/pnas.1219302110
Source type	Research Article
Keywords	ACC activity, GNG tests, response inhibition, probability of rearrest

Summary of key points + notes (include methodology)	This article studied if brain activity could predict future rearrest of criminals who were released. To do this, they looked at the activity in the anterior cingulate cortex (ACC), which is a region of the brain that helps people control their impulses. They studied 96 male offenders who took psychological tests and completed Go/No-Go (GNG) tests while having their brains scanned by fMRI machines. In the Go/No-Go test, the offenders were supposed to click a button when they saw the letter "X" but not when they saw the letter "K." The fMRI machines monitored their behavioral impulsivity during the task. After 4 years, the researchers discovered that 53% of the offenders were arrested again somewhere in that time period. Of the people who were rearrested, individuals who had lower ACC activity when they made a mistake in the GNG test were arrested sooner and more often than those with higher ACC activity. This article suggests that there is a correlation between ACC activity and future criminality, which is worth researching further.
	
	• Used 96 males released from incarceration
	• Performed error monitoring tasks while under fMRI after release
	  ○ Go/No-Go response
	• Measured neural activation in regions associated with error processing, such as the anterior cingulate cortex
	• Also measured behavioral, demographics, and psychological risk factors
	• MRI acquisition:
	  ○ Offender fMRI data was collected using a mobile 1.5T Siemens scanner
	  ○ Motion correction, spatial normalization, and smoothing were performed
	  ○ Brain activity was modeled for commission errors
	  ○ A separate 3T scanner was used for a nonoffender comparison sample

	• Findings
	  ○ 47.9% of participants were rearrested with the 4 yr period
	  ○ Lower activation in ACC during the task was associated with higher chance of rearrest (almost double the chance)

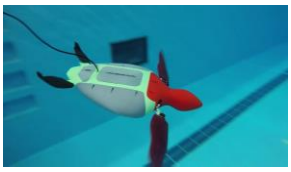
Research Question/Problem/ Need	Can future criminal activity of former criminals be predicted through brain activity?
Important Figures	 Cox survival function showing proportional rearrest survival rates of high (solid green) vs. low (dashed red) ACC response groups for any crime over a 4-y period
VOCAB: (w/definition)	Omnibus effect: the outcome or impact of such a comprehensive measure that assesses overall differences among multiple groups Covariate: an independent variable that can influence the outcome of a given statistical trial, but which is not of direct interest
Cited references to follow up on	GT Harris, ME Rice, VL Quinsey, Violent recidivism of mentally disordered offenders: The development of a statistical prediction instrument. Crim Justice Behav 20, 315–335 (1993). AC Janes, et al., Brain reactivity to smoking cues prior to smoking cessation predicts ability to maintain tobacco abstinence. Biol Psychiatry 67, 722–729 (2010).
Follow up Questions	• Is there a way to intervene in ACC activity? Will that allow us to manipulate the probability of recidivism? • Can this same method be used to detect relapses in alcoholism and drug use?

Article #3 Notes: Prosthetic fin could save injured rare turtles

Source Title	phys.org
Source citation (APA Format)	AUT University. (2021, March 30). *Prosthetic fin could save injured rare turtles*. Phys.org. https://phys.org/news/2021-03-prosthetic-fin-rare-turtles.html
Original URL	https://phys.org/news/2021-03-prosthetic-fin-rare-turtles.html
Source type	Scientific News Article
Keywords	Prosthetic fin, motion sensors, sea turtle kinematics, robotic turtle

Summary of key points + notes (include methodology)	This article relays how researchers at AUT's BioDesign Lab created a prosthetic fin for sea turtles, which are often injured by boats and other human equipment. They mimicked sea turtle fin kinematics and geometry and determined that the natural fin shape worked the best. The final design consisted of a 3D-printed skeleton made of titanium alloy covered with molded polyurethane rubber. It's designed to be implanted at the turtle's humerus bone through a stem implant procedure. A robotic turtle prototype was made to test its swimming ability and was monitored through motion sensors in a pool. The team's design was approved for clinical trials and will be tested in living turtles, with each design custom-fitted. The team hopes that this prosthetic fin can be used in rescue centers and by veterinarians around the globe.
	
	• Design process:
	  ○ Created mathematical models for 3 swimming modes
	  ▪ General swimming
	  ▪ Power stroke
	  ▪ Vigorous swimming
	  ○ Tested various geometries (rectangular to airfoil to optimized bio mimicked shapes)
	  ○ Built a robotic turtle to compare simulated swimming to real motion
	• Prosthetic Fin:
	  ○ Made of molded polyurethane rubber over a 3D printed titanium skeletal structure
	  ○ Sent for trial in turtles at Canary Islands

Research Question/Problem/ Need	How can a more efficient and effective prosthetic fin be made for sea turtles?

Important Figures	 robotic turtle used to validate their design
VOCAB: (w/definition)	Stem implant: a long, rod-shaped component of a larger joint replacement or other medical device that is inserted into a bone's central canal (medullary canal) to provide stability and support for the prosthesis or device
Cited references to follow up on	Bernstein, A. (2014, May 17). *Israeli team designs prosthetic fin to save turtle*. Phys.org. https://phys.org/news/2014-05-israeli-team-prosthetic-fin-turtle.html
Follow up Questions	• Can these be made more generalized and usable by different turtle species? • Can this prosthetic detect damage and alert people so that it can be fixed?

Article #4 Notes: A New Era for Bionic Limbs

Source Title	IEEE.org
Source citation (APA Format)	Zara, A. (2023, March 28). *A New Era for Bionic Limbs*. IEEE Pulse. https://www.embs.org/pulse/articles/a-new-era-for-bionic-limbs/
Original URL	https://www.embs.org/pulse/articles/a-new-era-for-bionic-limbs/
Source type	News Article
Keywords	Bionic limbs, soft robotic materials, control, feedback, measuring user intent

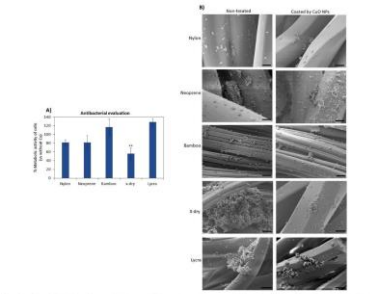
Summary of key points + notes (include methodology)	Traditional prostheses are increasingly abandoned because of their weight, low functionality, and discomfort. Researchers are working towards creating robotic prosthetics that react based on user signaling. PSYONIC's hand prosthetic, Ability Hand, uses soft robotic materials such as silicone and rubber to mimic human hands. This also makes it durable and lightweight. The fingers of the hand have sensors that give users vibration-based feedback. The Utah Bionic Leg was designed with springs and compliant materials to work similar to a regular leg. It is half the weight of traditional leg prosthetics, making it easier for users to walk. But a main challenge in prosthetics is the problem of control. Researchers are looking into using magnets to detect changes in muscle length, attaching bionic limbs to residual bone, and implanting electrodes to help users control the limbs with ease. By combining materials such as AI, motors, 3D printing, and sensory technologies, researchers aim to make prosthetics more like biological limbs.
	
	To solve the problem of control:
	• PSYONIC had a technique that would enable surgeons to attach a bionic finger to patient residual bone
	  ○ A titanium implant connects device to bone
	  ○ Artificial tendon attached to residual tendon would allow user to control prosthetic finger with their own muscle
	• Another technique uses magnets that detects changes in muscle length
	  ○ Implants 2 magnets along the muscle and used magnetometers to get data on the distance between the two magnets
	  ○ When the muscle contracts or changes position, the magnets will move
	• Implants also provide users with touch and proprioception

Research Question/Problem/ Need	How can prosthetic limbs be made more like our biological limbs and give the user control of them?

Important Figures	 Tommaso Lenzi, Ph.D., works with a participant to test the Utah Bionic Leg
VOCAB: (w/definition)	Electrodes: a conductor through which electricity enters or leaves an object, substance, or region Proprioception: the body's ability to sense its position and movement in space without relying on vision Actuator: a machine that moves or controls components in a system by converting energy into physical motion
Cited references to follow up on	A. Akhtar, "3D-printing hands that feel," GetMobile, Mobile Comput. Commun., vol. 24, no. 4, pp. 10–16, Mar. 2021, doi: 10.1145/3457356.3457360. C. R. Taylor et al., "Untethered muscle tracking using magnetomicrometry," Frontiers Bioeng. Biotechnol., vol. 10, p. 1979, Oct. 2022, doi: 10.3389/fbioe.2022.1010275.
Follow up Questions	• Can brain signals be read to control the limbs? • Can bionic limbs be made to sense temperature and "pain"?

Article #5 Notes: Antibacterial evaluation of different prosthetic liner textiles coated by CuO nanoparticles

Source Title	Heliyon
Source citation (APA Format)	Najmi, Z., Nives M. M., Alessandro C. S., Cochis, A., Selmani, A., Aleksander U., Abram, A., Zore, A., Delač, I., Jerman, I., Van, N., Vidmar, J., Klemen B., & Rimondini, L. (2024). Antibacterial evaluation of different prosthetic liner textiles coated by CuO nanoparticles. *Heliyon*, *10*(1), 23849–23849. https://doi.org/10.1016/j.heliyon.2023.e23849
Original URL	https://www.sciencedirect.com/science/article/pii/S2405844023110577
Source type	Journal Article
Keywords	Prosthetic liners, Textile, Copper, Nanoparticle, Antibacterial, Cytocompatibility
#Tags	
Summary of key points + notes (include methodology)	Prosthetic liners are used between residual limbs and prosthetic sockets but can create an environment that causes bacterial growth, leading to infections. This study explores the use of CuO nanoparticle-coated textiles as a solution to this problem. The study selects various textile material to be coated with CuO. CuO nanoparticles were synthesized and checked for size and antibacterial activity. The surface of the coated textiles was analyzed with SEMs and an energy-dispersive X-ray was used to analyze the chemical composition of the textiles. The antibacterial properties were evaluated against common bacterial stains. SEM and EDX analyses showed successful coating of textiles with uniform distribution and proper chemical composition. The textiles showed significant antibacterial activity. This study suggests that CuO nanoparticle-coated textiles could be a good option for enhancing the antibacterial properties of prosthetic liners. • Prosthetic liners provide damp, moist areas for bacterial & fungal pathogens to grow and cause irritation & infection • There are many liner materials, and many are incorporated with antibacterial agents • Nanoscale materials (metallic/metallic oxide nps) make it harder for bacterial cells to mutate and develop resistance ○ Zinc oxide, Cu, Ag, CuO, Cu2O lots of antibacterial activity against gram-positive/negative strains • **Explains**: how CuO nanoparticles can be made • Hydrophobicity of CuO NP-coated materials-->measured through contact angle between surface of materials and a drop of water

	○ Natural hydrophobicity of the materials reduces bacterial attachment • Surface charge--> measured through zeta potential ○ x-dry and neoprene had more negative surface potential, which repulses bacterial cells of S. epidermidis • Test for Antibacterial activity ○ Used gram-positive S. epidermidis ○ Analyzed using metabolic activity with colorimetric alamar blue assay ○ Viable cells will reduce to a pink and fluorescent component called resorufin ○ The fluorescence intensity of resorufin was measured using a spectrophotometer ○ Viable surface-ashered bacteria were counted with CFU assay ▪ CFU: (number of colonies × dilution factor) × 10^serial dilution ○ Found that amount of adhered bacteria decreased by 60% ○ • Cytocompatibility: ○ Used mesenchymal stem cells from human bone marrow ○ Cells put on material surfaced and incubated ○ Metabolic activity of cells evaluated using assay alamar blue ○ Results: didn't affect some materials but reduced cytocompatibility by 40-50% for others • No cytotoxic effect was detected through the use of CuO • The material is a good candidate for being a prosthetic liner material
Research Question/Problem/ Need	Can lining prosthetic liner materials with CuO reduce the physical and biological damages that are caused due to direct contact with prosthetic liners?
Important Figures	
VOCAB: (w/definition)	Cytocompatibility: the property of a substance or material to not be harmful to cells and to maintain their normal structure and function Zeta potential: measures the electrostatic potential at the shear plane (or slipping plane) around a particle in a liquid, acting as a key indicator of the magnitude of electrostatic repulsion between particles and, therefore, the stability of a dispersion or emulsion Confluency: refers to the proportion of the culture dish or flask covered by

	adherent cells
Cited references to follow up on	J.M. Haglin, D.R. Garcia, D.L. Roque, C.S.L. Spake, J.D. Jarrell, C.T. Born, Assessing the efficacy of a silver carboxylate antimicrobial coating on prosthetic liners, Journal of Prosthetics and Orthotics 32 (2020) 251–257, https://doi.org/10.1097/JPO.0000000000000271. X. Yang, R. Zhao, D. Solav, X. Yang, D.R.C. Lee, B. Sparrman, Y. Fan, H. Herr, Material, design, and fabrication of custom prosthetic liners for lower-extremity amputees: a review, Med Nov Technol Devices 17 (2023), 100197, https://doi.org/10.1016/j.medntd.2022.100197
Follow up Questions	• How did they coat the materials with CuO? • What other things are necessary to be tested to evaluate a prosthetic liner material?

Article #6 Notes: Functionalization of Bacterial Cellulose with the Antimicrobial Peptide KR-12 via Chimerical Cellulose-Binding Peptides

Source Title	International Journal of Molecular Sciences
Source citation (APA Format)	van Zyl, E. M., & Coburn, J. M. (2024). Functionalization of bacterial cellulose with the antimicrobial peptide KR-12 via chimerical cellulose-binding peptides. *International Journal of Molecular Sciences*, *25*(3), 1462–1462. https://doi.org/10.3390/ijms25031462
Original URL	https://www.mdpi.com/1422-0067/25/3/1462
Source type	Journal Article
Keywords	KR-12; antibacterial activity; bacterial cellulose; antimicrobial peptides; cellulose binding peptides; wound dressing
#Tags	
Summary of key points + notes (include methodology)	There is an increase in drug-resistant bacteria which has increased the need for more antibacterial materials. Bacterial cellulose is known for its biocompatibility and is promising for such applications. However, it lacks antimicrobial properties which are necessary for functionalization in such areas such as dressing for chronic wounds. The study explores the integration of BC with KR-12, an antimicrobial peptide, through the addition of chimeral cellulose-binding peptides. These peptides attach KR-12 to the BC, giving it antibacterial properties. The functionalized BC was characterized using many techniques to evaluate its structural and antimicrobial properties. The functionalized BC showed antibacterial activity against bacterial strains. However, the level of inhibition was not enough to be considered clinically effective. The KR-12 peptide was successfully bound to the cellulose without significantly altering its properties, suggesting potential for further possibilities to optimize its antibacterial properties. INTRODUCTION: • Problem: chronic wounds are dangerous because they deteriorate the marked cell populations. Current treatments, such as antiseptics, impede cell proliferation and migration of natural healing processes. Overall, these solutions hinder cellular proliferation and result in increased antibiotic resistance.

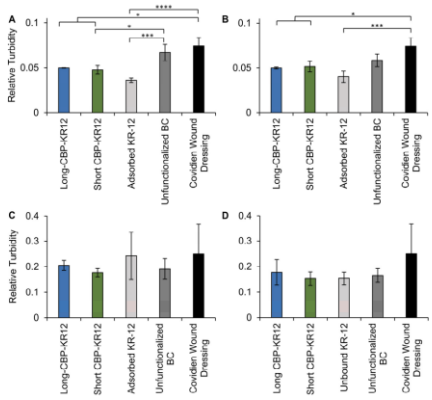
- Antimicrobial Peptides(AMPS): are positively charged and cause damage to microbial cell wall through the electrostatic interaction between the +AMP and –bacterial membrane
    - Many agents have this quality but have high cytotoxicity--> KR-12 overcomes these limitations (good antibacterial agent, good cytotoxicity, shorter peptide chain so less likely to be broken down by enzymes)
- BC good for: biocompatibility, water-retention, gas exchange, handleability
- BC lacks antimicrobial properties
- Cellulose binding peptides (CBPs) bring certain enzymes close to cellulose so that enzymes can break it down-->use CBPs to attatch AMPs to surfaces like BC
    - AMPs are normally cytotoxic so using CBPs keeps the AMPs in place to prevent infection but not harm human cells
- This work uses two CBP sequences: Long-CBP & Short-CBP
    - Long-CBP: engineered by Khazanov et al. to have higher cellulose-binding affinity and more surface coverage
    - Short-CBP: found to have cellulose binding through CH/pi interaction and H bonding between peptide side chains and cellulose
- THIS WORK: first reported use of CBPs to hold KR-12 to a material surface

RESULTS/DISCUSSION

- KR-12 attached to N-terminus (start of peptide) of long CBP and Short CBP to form Long/Short-CBP-KR12
- Designed hybrid/chimeric peptides with CBP, flexible linker, KR-12
- Use I-TASSER to predict 3D structure of the peptides
    - KR12 has strong a-helix but CBPs alone don't have much
    - LONG-CBP has small helical region and long-CBP-KR12 forms a longer a-helix
- Evaluate how structure affects function through analyzation of a-helix, amphiphilicity, charge, hydrophobic moment (how amphiphilic it is)
- Helical Wheel Diagrams:
    - KR12 shows separation between polar and non-polar, giving it amphiphilicity
    - Chimeric peptides maintain amphiphilic pattern in KR12 region
- Hydrophobic moment:
    - KR-12: 0.782 → high amphiphilicity (good for antibacterial activity)
    - LL-37: 0.440 → lower than KR-12
    - Long-CBP-KR12: 0.387
    - Short-CBP-KR12: 0.346
- Charge: + charge is good

- KR12=+4
- CBPs alone: pH=7
- Chimeric: +4

- Circular dichroism spectroscopy to study secondary structure:
  - Does this by measuring how peptide absorbs light, especially (~190-250nm)
  - a-helix: two dips at ~208nm and 222nm and one peak at ~192nm
  - Tested KR-12 in a phosphate buffer (control), phosphate buffer +0.1% LPS to mimic bacterial membrane, phosphate buffer + 50% TFE which encourages a-helices
    - Control&LPS: some a-helical but not string (49%+-7% of a-helix structure)
    - TFE: stronger dips so more a-helix formation (56%+-6% of a-helix structure)
- Both chimeric peptides had high helicity in all solutions
- For cytotoxicity assessments, NHDFs(Normal Human Dermal Fibroblasts/skin cells) are the common standard
  - Metabolic activity proportional to cell count
  - Results normalized to a control (untreated=100%)
  - Higher concentrations of KR-12=more cell growth-->
    - Day3:
    - 40 µM: 121% ± 20%
    - 80 µM: 125% ± 10%
    - 5 µM: only 86% ± 18%
- Long-CBP-KR12 exhibited no effects on metabolic activity through all concentrations but Short-CBP-KR12 showed increased cytotoxicity with concentrations>=20uM
- Antibacterial activity was measured against S.aureus, E.coli, P. Aeruginosa and the through minimum inhibitory concentration (MIC)
- The chimeric peptides were found to need a bigger MIC meaning that a higher peptide concentration was needed to inhibit bacterial growth which was predictable because of all the additional amino acids added to the AMP
- Tested its ability to counteract effects of endotoxins by assessing the peptides' ability to inhibit LPS induced activation if the LAL enzyme
  - Long-CBP-KR12 resulted in increased LPS detection
  - Short-CBP-KR12 had a decrease in LPS detection (means it did bind to a lot)
- Cellulose binding capacity:
  - BC comes into 2 forms—opaque and transparent with opaque usually having higher binding
  - Used fluorescent tags to track amt of peptide bound to BC by measuring fluorescence left in the solution (less in solution = more on BC)
  - Long-CBP-KR12 had improved binding over just the Long-CBP

	and more bound to opaque ○ Short-CBP-KR12 has best binding overall probably because of its smaller size that might allow more peptides to cover BC surface ○ Shows CBPs improve binding stability • Long-SHort-CBP-KR12 have no negative effects on metabolic activity but can promote cell proliferation • Opaque BC functionalized with Long/Short-CBP-KR12 reduced E.coli growth by 33 and 36% respectively • In this study, KR-12 was immobilized via C-terminal using a glycine-rich flexible linker and a CBP to anchor to BC surface ○ Resulted in decreased E.coli growth but antibacterial effect wasn't strong enough to be considered clinically effective ○ This is still a promising approach and improvements of antibacterial activity other things could be explored: alternative KR-12 analogs, backbone-cyclized KR-12 dimers, and chemically modified KR-12
Research Question/Problem/ Need	How does CBP-driven immobilization of AMPs affect antimicrobial properties of BC when integrated?
Important Figures	 Figure 8: Tested antibacterial effect of functionalized BC against E.coli (A&B) and P.aeruginosa (C&D) Opaque BC in A&C and Transparent BC in B&D Measured in relative turbidity which aids bacterial growth, so higher turbidity means more bacteria This was measured after 12 hrs and data averages from 3 experiments
VOCAB: (w/definition)	**Chimeric peptides:** artificial peptides created by covalently linking parts of at least two different natural peptides or proteins to enhance biological activity, selectivity, or to achieve new functions **LPS (lipopolysaccharide) binding capability**: refers to the ability of certain proteins or immune receptors to specifically recognize and bind to lipopolysaccharides, which are the main components of the outer membrane of Gram-negative bacteria. This binding is a crucial step in the host's innate

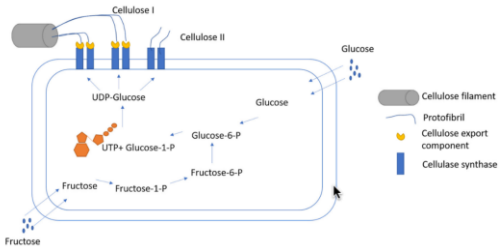
	immune response to bacterial infections **Senescence:** the condition or process of deterioration with age. **Cationic amps:** antimicrobial peptides (AMPs) that have a net positive electrical charge and are amphiphilic, meaning they have both positively charged and hydrophobic (water-repelling) regions. These molecules interact with the negatively charged surfaces of microbial membranes, disrupt them, and cause the microbes to die. **Linker:** a short sequence of amino acids (in this case, rich in glycine (G) and serine (S)) placed between the CBP and KR-12 parts **Amphiphilicity**: the property of a molecule having both hydrophilic (water-loving) and hydrophobic (water-repelling) parts **Helical wheel diagram:** a way to visualize how amino acids are arranged around the spiral of the α-helix
Cited references to follow up on	van Zyl, E.M.; Kennedy, M.A.; Nason, W.; Fenlon, S.J.; Young, E.M.; Smith, L.J.; Bhatia, S.R.; Coburn, J.M. Structural properties of optically clear bacterial cellulose produced by Komagataeibacter hansenii using arabitol. Biomater. Adv. 2023, 148, 213345. [CrossRef]
Follow up Questions	• Why use short vs large CBP? What is this difference helping with in the experiment? • Is there potential for using CBP-linked antimicrobial peptides like KR-12 in non-wound biomedical devices, such as prosthetic liners, which require infection prevention but also long-term contact? • The antimicrobial effects seemed to differ between opaque and transparent BC, especially with E. coli growth reduction trends. What differences in BC structure or peptide accessibility could have contributed to this variation?

Article #7 Notes: Bacterial Cellulose: Production, Characterization, and Application as Antimicrobial Agent

Source Title	International Journal of Molecular Sciences
Source citation (APA Format)	Lahiri, D., Nag, M., Dutta, B., Dey, A., Sarkar, T., Pati, S., Edinur, H. A., Abdul Kari, Z., Mohd Noor, N. H., & Ray, R. R. (2021). Bacterial cellulose: Production, characterization, and application as antimicrobial agent. *International Journal of Molecular Sciences*, *22*(23), 12984. https://doi.org/10.3390/ijms222312984
Original URL	https://pmc.ncbi.nlm.nih.gov/articles/PMC8657668/
Source type	Journal Article
Keywords	natural polymer; biocomposite; nanocomposite; antimicrobial; antibiofilm
#Tags	

Summary of key points + notes (include methodology)	Bacterial cellulose (BC), a biopolymer produced by certain bacteria, offers many properties such as high purity, biocompatibility, and good structure. However, it lacks antimicrobial activity. This review examines production methods of BC and dives into techniques used to assess BC's physical, chemical, and mechanical properties. It also goes into strategies to enhance BC's antimicrobial properties, such as chemical modification, antimicrobial agents, and surface functionalization. Current modified BC materials show potential in areas such as wound dressing, drug delivery, and tissue engineering scaffolds. However, this articles says that further research is necessary to modify these materials for clinical use.
	
	• BC already being used for food packaging
	• H bonds, parallel stacking, microfibrillar (bundles of chains) structure promotes hierarchical orders that give high mechanical strength to cellulose
	• BC can be produced by Agrobacterium spp., Acetobacter spp., Azotobacter, Rhizobium spp., Sarcina, Alcaligenes, and Pseudomonas, Komagataeibacter
	• Fermentation for productions happens in static or stirred modes
	• Static
	  ○ 3D interconnected reticular pellicles formed
	  ○ Regulated by supply of carbon and air into medium
	  ○ BC increases with tie and C-H bonding

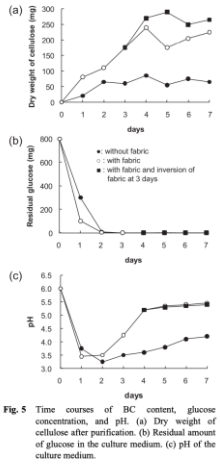
	- Formation of pellicle at air-liquid interface - optimized culture media required for production of BC include 0.5 wt% peptone, 0.5 wt% yeast extract, 0.27 wt% Na2HPO4, 2.0 wt% glucose, and 0.115 wt% citric acid - Stirred - Sharp irregular sphere-like particles (SCP) are produces - Develop and stay suspended in culture media - Impure raw pellets of BC are removed and then the pellets are washed with DI water - The fermentation medium is incubated for 1-14 days in pH4-7, 28-30 degrees C - Temperature range: 25-30 C and more specific depend on bacteria strain - PH 4-6 / acidic to near-neutral is good - Culture Media: - Carbon in the form of a compound such as fructose - Vitamins regulate cellular metabolism and growth - Agitation rate: moderate rpm is suitable ---too less or too much produce less BC - O2 necessary for cellular metabolism and BC growth and quality 10% saturation of dissolved O2 provides highest yield - BC lacks antibacterial properties, optical transparency, and stress-bearing capability - BC composites are synthesized with reinforcement materials added into it - SEM:helps provide structural morphology of BC - DSC: helps determine BC stability - FFS: helps analyze viscosity of BC MC & WVP: helps estimate water resistance capacity of film - Electrospun nanofibers containing BC with antimicrobial agents have shown better antibacterial performance - BC-grapheneoxide-CuO nanocomposites have greater efficacy than BC-CuO (also better biocompatibility and antibacterial material) - Tannic acid (TA) inhibits bacterial signaling, stopping biofilm formation - Incorporating TA into BC decreases microbial activity (BC-TA-Mg) - Polyhexanide, octenidine dihydrochloride, benzalkonium chloride, tetracycline, amoxicillin, povidone iodine, lysozyme, dehydrogenative polymers, zinc oxide, and gold nanoparticles are the few compounds that are good with BC
Research Question/Problem/ Need	What are the antimicrobial and antibiofilm properties of bacterial cellulose and its composites? How is BC produced and what are its unique features?

Important Figures	 **Figure 2.** Biosynthesis of cellulose I and cellulose II from glucose and fructose in bacterial cell.
VOCAB: (w/definition)	Pellicle: a thin skin, membrane, or film Consortium: an association of two or more different types of microbes that live and interact together Efficacy: the capacity of an intervention or substance to produce a desired beneficial effect in controlled, ideal conditions
Cited references to follow up on	Iqbal, H.M.N.; Kyazze, G.; Locke, I.C.; Tron, T.; Keshavarz, T. In Situ development of self-defensive antibacterial biomaterials: Phenol-g-keratin-EC based bio-composites with characteristics for biomedical applications. Green Chem. 2015, 17, 3858–3869. Sani, A.; Dahman, Y. Improvements in the production of bacterial synthesized biocellulose nanofibres using different culture methods. J. Chem. Technol. Biotechnol. 2010, 85, 151–164.
Follow up Questions	• Which BC composites have the highest level of antimicrobial activity? • Which are the most biocompatible?

Article #8 Notes: Creation of Bacterial Cellulose-Fabric Complexed Material

Source Title	Electronic Journals Library
Source citation (APA Format)	Mizuno, M., Kamiya, Y., Katsuta, T., Oshima, N., Nozaki, K., & Amano, Y. (2012). Creation of bacterial cellulose-fabric complexed material. *The Society of Fiber Science and Technology*, *68*(2), 42-47.
Original URL	https://www.jstage.jst.go.jp/browse/fiber
Source type	Journal Article
Keywords	Bacterial Cellulose, Biocomposites, Viscose rayon fabric, scaffold
#Tags	
Summary of key points + notes (include methodology)	Bacterial cellulose produced by *Gluconacetobacter xylinus* has useful properties, but it's hard to integrate into fabrics for functional materials. This article sought to create materials that combined BC with conventional fabrics. Nine types of fabric (cotton, viscose rayon, wool, silk, nylon, polyester, Kevlar, etc) were soaked in a culture medium with *G. xylinus*. These fabrics acted as scaffolds for bacterial cellulose to form and grow on the fabric surfaces. After cultivation, the composites were purified through alkaline treatment and then dried. In one variation of the process, viscose rayon fabrics were inverted during cultivation to direct BC growth on both sides of the fabric. BC had the greatest affinity for cotton and viscose rayon. All fabric were able to be uniformly coated by a BC sheet and inverting the fabric helped BC grow on both sides of the fabric. • BC has a fine and pure fiber network structure • In this study, G. xylinus was cultured on fabric soaked in culture medium to create a new BC bio-composite • G. xylinus was grown in SH medium which had 20 g/L glucose, 5g/L yeast extract, 5g/L polypeptone, Na2HPO4*12H2O and 0.115 g/L citric acid at 25 degrees Celcius • Fabrics: wool, silk, cotton, acetate, nylon, polyester +two non-woven fabrics---viscose rayon & Bemlise • Fabrics were prepped and purified • To test affinity of BC for these fabrics, the fabrics were cultured with G. xylinus • BC had an affinity for cotton, viscose rayon, Bemlise • BC was only observed on the top of fabric surfaces, so they decided to invert the fabric in the middle of BC cultivation • When the stack of viscose rayon was inverted at 3 days, both sides were

	evenly coated with BC sheet
	• The presence of viscose rayon fabric increased cellulose production by ~3x
	  ○ Changes metabolism of gluconic acid
	• Viscose rayon is most compatible for a BC bio-composite
	  ○ Had shiny surface, physical intensity, and high water absorption

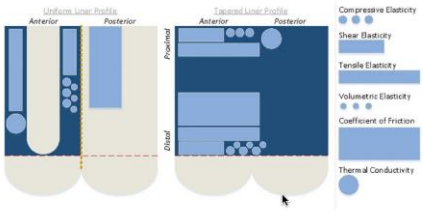
Research Question/Problem/ Need	• What fabric material is most suitable to be a scaffold for creating a bio-composite of BC and fabric?
Important Figures	**Table 1** Affinity of BC for various fabrics Cloth type — Affinity *Fabric* Wool - Silk - Cotton + Cellulose acetate - Nylon - Polyester - Kevlar® - *Nonwoven fabric* Viscose rayon ++ Bemliese® ++ +: weak interaction, ++: strong interaction  **Fig. 5** Time courses of BC content, glucose concentration, and pH. (a) Dry weight of cellulose after purification. (b) Residual amount of glucose in the culture medium. (c) pH of the culture medium.
VOCAB: (w/definition)	Scaffold: a temporary, three-dimensional structure, either biological or artificial, that provides support and guidance for cells to grow, differentiate, and form new tissue
Cited references to follow up on	C. Wiegand, P. Elsner, U. Hipler, and D. Klemm, *Cellulose*, **13**, 689 (2006).
Follow up Questions	• Why is BC integrated with fabric better for medical applications? • What are the properties of the fabric & BC material? Is it more flexible?

Article #9 Notes: Characterization of Prosthetic Liner Products for People with Transtibial Amputation

Source Title	National Library of Medicine
Source citation (APA Format)	Cagle, J. C., Hafner, B. J. & Sanders, J. E. (2018). Characterization of prosthetic liner products for people with transtibial amputation. *Journal of Prosthetics and Orthotics*, *30*(4), 187–199. https://doi.org/10.1097/JPO.0000000000000205
Original URL	https://pmc.ncbi.nlm.nih.gov/articles/PMC6425736/
Source type	Journal Article
Keywords	Compressive, Shear, Volumetric, Tensile elasticity, Coefficient of Friction
#Tags	

Summary of key points + notes (include methodology)	Practitioners often choose specific liner products routinely, despite the many prosthetic liners commercially available. This problem occurs because of the lack of data on their material properties. This study aims to characterize important mechanical and physical properties of commonly used prosthetic liners. The authors selected commercially available liners made of polyurethane, silicone, and thermoplastic elastomer (TPE). They measured 6 main properties: compressive elasticity, shear elasticity, tensile elasticity, volumetric elasticity, coefficient of friction, and thermal conductivity. They also looked at how fabric backings and liner thickness can influence these properties. They found that polyurethane and silicone liners had higher stiffness in compression and shear and TPE liners had higher tensile stiffness in most cases. Fabric backings had big influence on tensile elasticity. Polyurethane liners had low CoFs. Liner thickness had small effects and all liner types had similar thermal conductivity.
	
	• Despite numerous available prosthetic liner products, practitioners only choose a select few for their patients
	  ○ Don't know how other liners compare to the ones they commonly use→ need for information helping practitioners distinguish between liners
	• The study uses commercially available prosthetic liners and tests them with 6 material property tests
	  ○ Compressive elasticity & shear elasticity---to understand liner's ability to distribute loads during walking
	  ○ Tensile elasticity tests---to measure liner's resistance to stretching during swing of gait

	○ Coefficient of friction (CoF) tests---to determine how the liner adheres to the residual limb ○ Thermal conductivity & volumetric elasticity tests---to test liner's adaptations to temp & volume fluctuations • Elasticity tests done with material testing machine • CoF conducted using planar friction tester • Thermal conductivity measured with guarded heat flow meter • Pieces were cut out of the prosthetic liners according to their thickness • Soft liners with low compressive elasticity will be more comfortable by distributing peak pressures but a stiff liner with high compressive elasticity will be more stable for limb-socket coupling • To test compressive elasticity, specimens were compressed to a 60% strain or 250 kPa stress • Increased tensile elasticity can decrease a liner's ability to conform to a shape of limb but can cause closer coupling of liner and limb, reducing pistoning • Liners with high CoF increases shear stresses to limb which can be bad for skin tissues ○ To test this, leather samples were pulled across the liners • High thermal conductivity=takes heat away • Low thermal conductivity = retains heat • Elastomeric liners are characterized according to their base polymer ○ 3 general types: polyurethanes, silicones, and thermoplastic elastomers • Polyurethane and silicone had comparable shear stiffness while TPE liners had lower stiffness • Polyurethane and silicone had comparable tensile stiffness while TPEs had higher • Polyurethane liners had lower CoFs while silicone and TPE had higher CoFs ○ For CoF, the present choice would be silicone over polyurethane • Thermal conductivity of all three groups was similar ○ Higher than sheep wool and comparable to leather • All materials were found to be essentially incompressible and in clinical applications, performance for the 3 groups would be the same in terms of volumetric elasticity • Tests had relatively low sensitivity to any changes in liner thickness • Over the past 16 years, polyurethane has become softer and less sticks and TPEs have higher tensile stiffness
Research Question/Problem/ Need	To characterize properties of prosthetic liner products and compare the findings with previously characterized liners

Important Figures	 **FIGURE 1.** Test specimen locations. Test specimens were removed from anterior regions of the liner when possible. For uniform gel thickness profiles, only a narrow acceptable source region (blue) was available for certain liner products (e.g., WillowWood Hybrid Select), because the mid-anterior region had a different fabric, while distal and posterior regions had different gel thickness (beige).
VOCAB: (w/definition)	Excised: having been cut out surgically Pistoning: the vertical movement of a residual limb within a prosthetic socket, causing friction and discomfort, and it's often due to an inadequate suspension system or a socket that is too large for the limb Poisson's ratio (v): the negative ratio of a material's transverse (side-to-side) strain to its axial (lengthwise) strain when under load, representing how much a material constricts or expands laterally when stretched or compressed.
Cited references to follow up on	Sanders JE, Zachariah S, Baker AB, et al. Effects of changes in cadence, prosthetic componentry, and time on interface pressures and shear stresses of three trans-tibial amputees. Clin Biomech. 2000; 15:684–694 Klute GK, Glaister BC, Berge JS. Prosthetic liners for lower limb amputees: a review of the literature. Prosthetics Orthotics International. 2010; 34(2):146–153. [PubMed: 20384553]
Follow up Questions	• Do these materials need to be tested for cytocompatibility? • If the materials get stretched, do they return to their initial size?

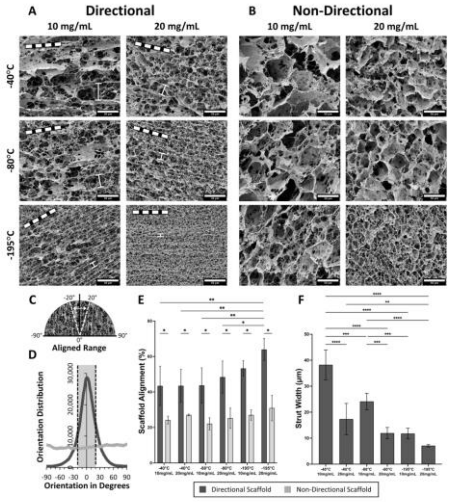
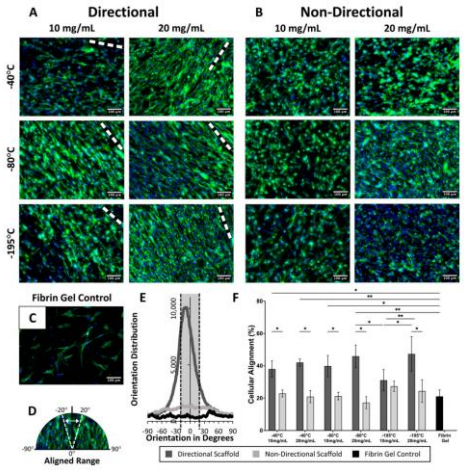
Article #10 Notes: Developing Porous Fibrin Scaffolds with Tunable Anisotropic Features to Direct Myoblast Orientation

Source Title	Mary Ann Liebert Publishers Journals
Source citation (APA Format)	Samolyk, B. L., Pace, Z. Y., Li, J., Billiar, K. L., Coburn, J. M., Whittington, C. F., & Pins, G. D. (2024). Developing porous fibrin scaffolds with tunable anisotropic features to direct myoblast orientation. *Tissue Engineering Part c Methods*, *30*(5), 217–228. https://doi.org/10.1089/ten.tec.2023.0363
Original URL	https://www-liebertpub-com.ezpv7-web-p-u01.wpi.edu/doi/full/10.1089/ten.tec.2023.0363
Source type	Journal Article
Keywords	anisotropy, fibrin, porous scaffold, skeletal muscle, guided cellular alignment, tissue engineering
#Tags	
Summary of key points + notes (include methodology)	Many tissues rely on biochemical and biophysical cues to direct cell function that promote tissue regeneration. However, after severe musculoskeletal injuries, these cues are lost. Current treatments have drawbacks and engineered scaffolds for this issue exist but have limitations such as inadequate tissue growth. This study focuses on the need for scaffolds that are porous, have microtopographic cues, and support myoblast alignment. The study uses fibrin, an ECM protein, as a basis for the scaffold and used directional freeze-casting to create alignment in the pore structure of the scaffolds. The researchers manipulated fibrin concentration, freezing temperature, and whether the freezing was directional. They examined the surface of the scaffolds, its behavior after hydration, its mechanical properties, and its degradation in proteolytic environments. Directional freezing was found to produce significant anisotropy and strut widths were influenced by fibrin concentration and freezing temperatures. Scaffolds shrunk upon hydration and increasing fibrin concentration increases the stiffness of the scaffolds. Myoblasts cultured on the directional scaffolds aligned along the anisotropic features. Therefore, porous fibrin scaffolds with anisotropic surfaces can be made through directional freeze-casting by manipulating fibrin concentration and freezing temperature. • 65.8 million Americans suffer from musculoskeletal injuries ○ Current treatment involves autologous tissue transfer (from intact

muscle to injury site)

- Severe musculoskeletal injuries can cause significant tissue damage and can lead to cells and ECM signaling cue destruction---stopping wound-healing that promotes tissue regeneration
- Fibrin is a native ECM protein that is often used as scaffold material for tissue engineering because of its biocompatibility, degradation rates, and bio inductive signaling cues at the initial stage of tissue regeneration
- Current fibrin scaffolds lack sufficient mechanical strength or limit cellular infiltration into fibrous networks
- Their goal is to make a fibrin scaffold with interconnected pores, anisotropic features, etc that is used with directional freezing techniques which haven't been used with fibrin before
- To make the fibrin scaffold:
    - Mixed bovine fibrinogen, thrombin, calcium chloride to form a fibrin gel
    - The gels were placed in 2 molds, a custom directional freezing model (with insulative walls and aluminum plates to direction freezing in 1 direction) and a nondirectional mold of polystyrene
    - The gels were frozen through 3 different sources:
        - -40 C = lyophilizer shelf
        - -80 C = dry ice
        - -195 C = liquid nitrogen
    - After freezing, they removed the water by freeze-drying with primary drying and secondary drying
    - Dried scaffold was cut into ~1mm thick slices
    - Scaffolds had either of 2 fibrin concentrations: 10 or 20 mg/mL
- Characterizing scaffold structure
    - Used scanning electron microscope to image the surface of the scaffold
    - To measure alignment (anisotropy)
        - They analyzed 3 random regions per scaffold and set the 0 degree axis to match the freezing direction
        - Then they calculated what % of features were oriented within +-20 degrees of the axis
    - Then they measured how thick each scaffold strut was
    - They also used light microscopy to observe how the structure was after soaking the scaffolds in PBS
- They used ethanol immersion to calculate the porosity of the directional scaffolds
- They calculated scaffold shrinkage by taking its dimension when dry, post hydration, and submerged in plasmin
- To test the hydrated scaffolds' material stiffness, the researchers used nanoindentation
    - Scaffold section were glued onto dishes, indented by a probe at 15 different points, and then calculated the stiffness according to their formula

	• They used immortalized mouse myoblasts
	• To evaluate the scaffolds' ability to direct myoblast orientation, C2C12 myoblasts were used
	  ○ The cells were fixed and stained and added to the scaffolds
	  ○ Imaging happened through a fluorescence microscope
	  ○ The Cell alignment was analyzed in similar method to characterization of scaffold structure
	RESULTS:
	• Strut widths of directional scaffolds decrease with increased fibrin concentration and lower freezing temps
	• All directional frozen scaffolds were significantly more aligned to the freezing direction than the nondirectionally frozen scaffolds
	• Scaffolds with smaller strut widths displayed less shrinkage than large strut widths
	• Porosity was not significantly different for any of the scaffold groups
	• For all scaffolds, there was a sharp decrease in area after 3 hrs in plasmin. After that, there was a gradual decrease in area
	• Higher fibrin concentration led to significantly stiffer scaffolds and colder freezing temps tended to reduce stiffness
	• Most directional scaffolds showed significant difference compared to the nondirectional scaffolds for the alignment of myoblasts
	• Directional freeze-casting can produce anisotropic features in fibrin scaffolds and can be modified with freezing temp and fibrin concentration
	• The ability to change the microtopography of porous fibrin scaffolds may help the regeneration of tissues for treatment of musculoskeletal injuries

Research Question/Problem/ Need	To create an implantable, off-the-shelf solution to severe musculoskeletal injuries that restores regenerative topographic and growth factor signaling cues.
Important Figures	 FIG. 2. Morphological characterization of lyophilized scaffolds. SEM images of directional (**A**) and nondirectional and (**B**) porous fibrin scaffolds. *White* dotted lines indicate freezing direction. *White* bars indicate anisotropic strut widths. Scale bars = 50 μm. (**C**) Schematic image depicting the aligned region relative to the freezing direction. (**D**) Representative orientation distribution graphs comparing directional and nondirectional scaffolds. Dotted lines indicate alignment region. (**E**) Quantification of scaffold alignment ($n = 6$). (**F**) Quantification of strut widths for directionally frozen scaffolds ($n = 4$). Mean ± SD, * indicates $p < 0.05$, ** indicates $p < 0.01$, *** indicates $p < 0.001$, **** indicates $p < 0.0001$. SEM, scanning electron microscopy, SD, standard deviation.  FIG. 5. C2C12 myoblast alignment on (**A**) directional and (**B**) nondirectional porous fibrin scaffolds. (**C**) Myoblast alignment on fibrin gel control. *White* dotted line indicates freezing direction. Scale bars = 100 μm. (**D**) Schematic image depicting the aligned region relative to the scaffold freezing direction. (**E**) Representative orientation distribution graphs comparing directional scaffolds, nondirectional scaffolds, and fibrin gel controls. Dotted lines indicate alignment region. (**F**) Quantification of percent cell alignment ($n = 6$). Mean ± SD, * indicates $p < 0.05$, ** indicates $p < 0.01$. SD, standard deviation.
VOCAB: (w/definition)	Anisotropy: a property of materials where their physical or optical properties,

	such as conductivity, refractive index, or mechanical strength, differ depending on the direction of measurement or applied stress Myoblasts: specialized skeletal muscle precursor cells, or muscle stem cells, that proliferate and differentiate into muscle fibers, forming the basis of muscle development, repair, and growth Microtopography: in scaffolds refers to engineered surface features at the micrometer scale, such as grooves, pillars, or depressions, designed to mimic the extracellular matrix (ECM) of native tissues and guide cellular behavior and tissue regeneration Myogenesis: the creation of new muscle cells (myocytes Angiogenesis: the formation of new blood vessels Lyophilized: freeze-dried, helps preserve structure and controls porosity
Cited references to follow up on	Brown AC, Barker TH. Fibrin-based biomaterials: Modulation of macroscopic properties through rational design at the molecular level. Acta Biomater 2014;10(4):1502–1514; doi: 10.1016/j.actbio.2013.09.008
Follow up Questions	• Why was fibrin chosen over other biomaterials for scaffold creation? • Can the directional freezing method be used on other polymers?

Article #11 Notes: Functionalization of bacterial cellulose wound dressings with the antimicrobial peptide ε-poly-L-Lysine

Source Title	IOPSCIENCE
Source citation (APA Format)	Fürsatz, M., Skog, M., Sivlér, P., Palm, E., Aronsson, C., Skallberg, A., Greczynski, G., Khalaf, H., Bengtsson, T., & Aili, D. (2018). Functionalization of bacterial cellulose wound dressings with the antimicrobial peptide *ε* -poly-L-Lysine. *Biomedical Materials*, *13*(2), 025014. https://doi.org/10.1088/1748-605x/aa9486
Original URL	https://iopscience.iop.org/article/10.1088/1748-605X/aa9486
Source type	Journal Article
Keywords	bacterial cellulose, antimicrobial, carboxymethyl cellulose, ε-poly-L-Lysine
#Tags	

Summary of key points + notes (include methodology)	Bacterial cellulose (BC) offers many useful properties, but its moist environment can promote bacterial growth, increasing risks of infection. In this study, researchers explored two methods for functionalized BC with ε-poly-L-Lysine, an AMP: one was where ε-PLL was directly cross-lined with BC using carbodiimide chemistry and another was where ε-PLL was conjugated with carboxymethyl cellulose (CMC) that was adsorbed onto the BC membranes. The success of the functionalization was confirmed through many techniques, including methyl red conjugation, FTIR spectroscopy, and XPS elemental composition analysis. These methods showed that ε-PLL penetrated the BC structure and covalently bonded without affecting its structure or mechanical properties. The antimicrobial membranes inhibited growth of *S. epidermidis* while keeping its cytocompatibility with human dermal fibroblasts. The modifications were stable under sterilization methods such as ethanol treatment and autoclaving. Overall, ε-PLL functionalized BC shows promise in wound applications but its ability to fight off *E. coli* could be further studied.
	
	• BC has the same chemical structure as cellulose but doesn't have impurities such as hemicellulose and lignin and has thinner fibers
	• BC has high chemical stability, high tensile strength and flexibility, large water holding capacity, permeability to gases/liquids, and biocompatibility
	• BC forms a soft and conformable layer
	  ○ Small pore size prevents bacteria from entering wounds
	  ○ Bacteria already present in the wound can thrive in moist environments created by BC

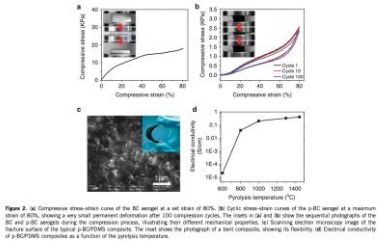
- Several strategies have been made to give BC antimicrobial properties: adsorb, covalently bind, or physically entrap antimicrobial compounds in BC
    - Ex: antibiotics, silver nanoparticles, chitosan, cationic antiseptics
    - Less investigated are AMPs
- ε-poly-L-Lysine is an AMP produced by *Streptomyces albulus*
    - non-toxic, water soluble, and biodegradable
    - ε-PLL disrupts the composition of the bacterial cell membrane which kills bacteria and reduces risk of resistant bacteria
    - ε-PLL needs to be chemically tethered to BC nanofibers or trapped within the fibrous matrix
- Some of methods of chemical functionalization are laborious and use organic solvents that require procedure under nitrogen atmosphere
    - Affect structure of cellulose fibers and mechanical properties
- 2 strategies will be used for functionalization of BC wound dressings:
    - ε-PLL covalently conjugated using carbodiimide chemistry to carboxymethyl cellulose (CMC) adsorbed to BC
    - crosslinking the ε-PLL within the BC network using carbodiimide chemistry to form an interpenetrating network (IPN)
- To functionalize BC:
    - BC membranes soaked in Milli-Q water to remove ethanol and prepare for modification
    - CMC was adsorbed onto BC membranes
    - Membranes were rinsed to remove unbound CMC
    - Attached Human Serum Albumin (HSA) to carboxyl groups on CMC-coated BC using carbodiimide chemistry
        - Forms covalent bond with carboxyl groups on CMC to amine groups on HAS
        - Confirmed surface was reactive and modifiable
    - To test stability of HAS coupling
        - Exposed to NaCl to see if protein was just non-covalently bonded, exposed to ethanol to simulate sterilization
        - Autoclaving-tested chemical/thermal stability
        - Showed it worked
    - Functionalized BC with and without CMC using ε-PLL (same process as with HSA)
    - To verify attachment of ε-PLL:
        - Used methyl red (MR) a dye that reacts with free amines
        - MR was activated using EDC/NHS chemistry and incubated with ε-PLL membranes
        - Presence of MR dye confirmed presence of ε-PLL since MR binds to amine groups
    - The adsorption o CMC was evaluated by conjugation of HAS to CMC-BC. The pronounced amide I and II bands of the protein indirectly quantified available CMC.
- BC without CMC showed little protein binding, showing CMC adsorption enabled conjugation of HAS

- Used a synthetic peptide similar in size to ε-PLL to simulate binding and peptide only stuck well with CMC
- To make BC antimicrobial, BC-CMC membranes were soaked in a solution of ε-PLL followed by a rinse and addition of EDC/NHS
- BC without CMC also did the same thing to test for differences
- Unlike BC with HAS or the coiled coil synthetic peptide, confirming ε-PLL presence with FTIR was harder because their configuration results in lower amide band intensities and the massive BC background signal
    - Therefore, a pH sensitive dye, MR, was bound to ε-PLL and because of MR's strong absorbance, MR bound to membrane could be detected using spectroscopy
    - High total absorbance = efficient conjugation of ε-PLL to BC fibers
- A high MR signal was also obtained for ε-PLL crosslinked in BC without CMC→ CMC was not required to retain ε-PLL
- ε-PLL molecules have 1 terminal carboxyl group + many amines, so it can crosslink by EDC/NHS to form an IPN within the BC membrane
- Tested the BC membrane with MR at different pHs and the color changed accordingly→this was measured at absorbance 460/550 nm which corresponds with MR's color state (yellow & red)
    - pH range of colorimetric response reduced to pH 2-4 because carboxyl group is used for conjugating MR to ε-PLL
    - color changes were visible and reversible→ COULD BE USED TO TRACK PH CHANGES
    - They used the dye to estimate penetration depth of the functionalization
        - Thicker BC-ε-PLL and BC-CMC-ε-PLL had penetrated to a depth of ~0.4 mm into the materials, clearly visible as a colored red or yellow rim surrounding an uncolored core
        - Thin BC membranes will have homogenous functionalization while thicker pieces will be more at the surface
- Elemental characterization:
    - Used XPS to determine elemental compositions of native BC, BC-ε-PLL and BC-CMC-ε-PLL membranes
    - Pure cellulose wouldn't contain nitrogen expect for minor impurities so increase in nitrogen would be attributed to bound ε-PLL
    - BC-CMC-ε-PLL membranes had the most increase in nitrogen so that means more ε-PLL is found in them
- Morphological characterization with SEM and AFM:
    - Fiber thickness was unchanged and no blocked pores so it's reasonable to say that the functionalization primarily forms thin layers surrounding each fiber
    - SEM and AFM indicate that the ε-PLL fibers have a slight increase in thickness and CMC fiber are slightly smaller
- Cytocompatibility

	○ Cultured human dermal fibroblasts (HDF) with BC, BC-CMC, BC- ε-PLL, BC-CMC- ε-PLL ○ HDF were used because of their importance in wound healing ○ Membranes were placed on top of the cultured cells ○ No differences in cell morphology/proliferation were observed • Antimicrobial effect: ○ Membranes were incubated in plates with *E. coli* and *S. epidermidis* ○ After incubation, BC and BC-CMC membranes were covered in bacteria while a significant reduction in growth of *S. epidermis* was seen on and near both ε-PLL functionalized membranes ○ It still maintained this and the effect even became more pronounced after 30 days, showing that it can be retained for long periods of time ○ Not much effect was noticed with the *E. coli* ▪ Likely because a higher concentration of ε-PLL is needed
Research Question/Problem/ Need	Can BC be functionalized with ε-PLL to give antimicrobial properties without affecting its mechanical integrity or cytocompatibility for use in wound care dressings?
Important Figures	
VOCAB: (w/definition)	Adsorb: (of a solid) hold (molecules of a gas or liquid or solute) as a thin film on the outside surface or on internal surfaces within the material Carbodiimides: work by activating carboxylic acids, forming a highly reactive O-acylisourea intermediate. This intermediate then readily reacts with a primary amine to form a stable amide bond. (covalently attach amine groups to carboxyl groups) Autoclave: a machine that uses steam under pressure to kill harmful bacteria, viruses, fungi, and spores on items that are placed inside a pressure vessel Fourier Transform Infrared spectroscopy (FTIR): a technique that uses infrared light to analyze the chemical bonds and functional groups within a sample, providing a unique "fingerprint" to identify substances Rheology: the science of the deformation and flow of matter, studying how materials respond to applied forces
Cited references to follow up on	SpaicM, Small D P,Cook J R andWanWK 2014Cellulose 21 1529 Vosmanska V, Kolarova K, Rimpelova S and Svorcik V 2014 Cellulose 21 2445
Follow up Questions	• Did the crosslinked e-PLL form a uniform distribution through the BC matrix or was it more concentrated? • Could the dye be used to create a pH measuring tool for wound dressings?

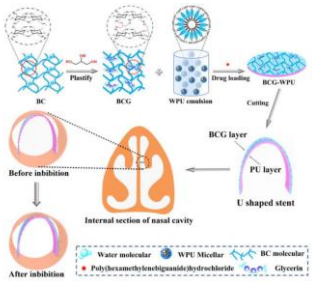
Article #12 Notes: Highly conductive and stretchable conductors fabricated from bacterial cellulose

Source Title	NPG Asia Materials
Source citation (APA Format)	Liang, H.-W., Guan, Q.-F., Zhu, Z. -, Song, L.-T., Yao, H.-B., Lei, X., & Yu, S.-H. (2012). Highly conductive and stretchable conductors fabricated from bacterial cellulose. *NPG Asia Materials*, *4*(6), e19–e19. https://doi.org/10.1038/am.2012.34
Original URL	https://www.nature.com/articles/am201234
Source type	Journal Article
Keywords	aerogels; bacterial cellulose; carbon nanofibers; electrical conductivity; pyrolysis; stretchable conductors
#Tags	
Summary of key points + notes (include methodology)	It is challenging to develop conductors that maintain their electrical conductivity under stretching and bending, which is essential for wearable and flexible electronics. Current solutions are expensive and unsuitable for large-scale manufacturing. Researchers decided to use a suitable material for their needs called bacterial cellulose (BC). They cultured and purified BC, then freeze-dried and pyrolyzed it to form a lightweight, 3D network structure. This p-BC was integrated in a silicone elastomer (PDMS) to create a stretchy composite. The resulting product showed high electrical conductivity and mechanical resistance, with small resistance changes under stretching, bending, and compression. The BC network kept its conductive pathways during deformation, demonstrating its advantage over traditional filler-based composites. The study states that bacterial cellulose is a cost-effective material for developing durable and stretchable conductors for use in flexible electronics. • BC good for this project: easy fabrication, low cost, mechanically robust 3D network structure • BC pellicles were cut into rectangles, frozen in liquid Nitrogen, freeze dried to become BC aerogels ○ Freeze dried to remove water • Then the aerogels were pyrolyzed to generate p-BC aerogels • p-BC/PDMS was made by infiltrating p-BC aerogels with PDMS pre-polymer, a mixture of base/curing agent, and then degassing it in a vacuum oven • After pyrolysis, p-BC obtained a 3D network structure but fiber

	diameter reduced to 10-20nm • Both BC and p-BC aerogels showed high flexibility • After both were compressed, BC aerogel couldn't return to its original shape but p-BC almost completely recovered • p-BC/PDMS made by infiltrating p-BC aerogels with the polymer resin under vacuum before curing it • the electrical conductivity of p-BC/PDMS and p-BC stayed the same, showing that the addition of PDMS had no effect on it • electrical conductivity of aerogels increased with the pyrolysis temperature • except the 1st cycle, the resistance of the aerogels showed no obvious change between each stretching-releasing cycle
Research Question/Problem/ Need	How can BC be used to fabricate highly conductive and stretchable composites which can be produced on an industrial scale?
Important Figures	
VOCAB: (w/definition)	Pyrolyze: make or become decomposed through heating to a high temperature Aerogel: a solid material of extremely low density, produced by removing the liquid component from a conventional gel
Cited references to follow up on	Yano, H., Sugiyama, J., Nakagaito, A. N., Nogi, M., Matsuura, T., Hikita, M. & Handa, K. Optically transparent composites reinforced with networks of bacterial nanofibers. *Adv. Mater*. 17, 153–155 (2005). Wan, Y. Z., Zuo, G. F., Yu, F., Huang, Y. A., Ren, K. J. & Luo, H. L. Preparation and mineralization of three-dimensional carbon nanofibers from bacterial cellulose as potential scaffolds for bone tissue engineering. *Surf. Coat. Technol.* 205, 2938–2946 (2011).
Follow up Questions	• What does the base/curing agent do when preparing the p-BC/PDMS composite? • What's the purpose of a vacuum oven?

Article #13 Notes: Design and characterization of plasticized bacterial cellulose/waterborne polyurethane composite with antibacterial function for nasal stenting

Source Title	National Library of Medicine
Source citation (APA Format)	Feng, Z., Li, M., Jin, X., Zheng, Y., Liu, J., Zhao, L., Wang, Y., Li, H., & Zuo, D. (2020). Design and characterization of plasticized bacterial cellulose/waterborne polyurethane composite with antibacterial function for nasal stenting. *Regenerative biomaterials*, *7*(6), 597–608. https://doi.org/10.1093/rb/rbaa029
Original URL	https://pmc.ncbi.nlm.nih.gov/articles/PMC7748449/
Source type	Journal Article
Keywords	bacterial cellulose; polyurethane; biocompatibility; nasal stent
#Tags	
Summary of key points + notes (include methodology)	This study focuses on the problem of discomfort and infection associated with nasal stents used post operation of surgeries for chronic rhinosinusitis. To solve this, the researchers decoded to create a composite material made of plasticized bacterial cellulose (BC) and waterborne polyurethane (WPU) with antimicrobial properties. BC was modified with glycerol to improve its flexibility and then combined with WPU to give it increase mechanical strength and elasticity. Poly (hexamethylene biguanide) hydrochloride (PHMB) was loaded into the membranes to give it antimicrobial activity. The composite was tested for its mechanical properties, water absorption, and antibacterial activity. The material was found to retain high flexibility and tensile strength, and it absorbed moisture. It could inhibit pathogens such as *S. aureus* for at least 12 days. The study concludes that BC-WPU composite had potential to be used to make better nasal stents that offer support and infection control. • Chronic rhinosinusitis causes many effects and surgery combined with nasal spray/antibiotics is the preferred treatment • However, this surgery had a high recurrence rate, and sinus stents are effective in reducing postoperative symptoms • Hard polymer materials for stents can have a helpful supporting effect but its strong strength and hardness can cause mucosa scratches • Waterborne polyurethane (WPU) is non-toxic, had good mechanical performance and biocompatibility • First, they constructed a 3D model of the nasal sinus structure using a CT scanned image of an adult male • Prepping BCG-WPU

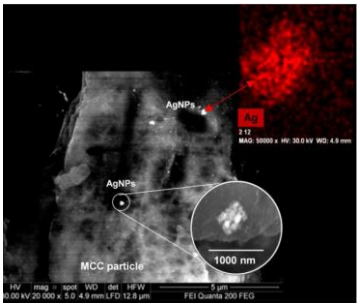
	○ Clean BC membranes ○ Use solvent exchange process with glycerol for plasticization ○ Membranes cut into round sheets and pressed btwn 2 polyterafluoroethylene plates ○ Then immersed in aqueous solution of glycerol and PHMB (for antimicrobial activity) for 24h ○ WPU synthesized and loaded with PHMB ○ The WPU emulsion was casted on BC and BCG sheets in an annular mold and then dried in a vacuum oven • Plasticizing BC into BCG weakens the hydrogen bonds between BC fibers, collapsing BC's network structure but allowing good adhesion between BCG and WPU • BCG-WPU had the highest water absorption ability (3x BC-WPU) • Tensile strength and elongation higher for BCG than BC • BCG-WPU had the highest maximum supporting force and expansion supporting force • For antibacterial activity, the zone of inhibition decreased after 12d but was still present • The extracts of WPU, BC and BCG have no significant cytotoxicity • BCG-WPU had less damage to nasal mucosa because if the BCG layer protecting the nasal mucosa after absorbing the mucus
Research Question/Problem/ Need	How can plasticized BC and WPU be functionalized with PHMB to give mechanical support and antibacterial activity for use in nasal stents?
Important Figures	
VOCAB: (w/definition)	Inoculate: introduce (cells or organisms) into a culture medium. Annular mold: a casting form used to create a ring-shaped medical device
Cited references to follow up on	Wu J, Zheng YD, Wen XX et al. Silver nanoparticle/bacterial cellulose gel membranes for antibacterial wound dressing: investigation in vitro and in vivo. Biomed Mater 2014;9:035005–12. Wang YS, Wang C, Xie YJ et al. Highly transparent, highly flexible composite membrane with multiple antimicrobial effects used for promoting wound healing. Carbohydr Polym 2019;222: 114985–14.
Follow up Questions	• What plasticizers do not affect the structure of BC? • How was PHMB loaded onto the membranes?

Article #14 Notes: Silicone Rubber and Microcrystalline Cellulose Composite with Antimicrobial Properties

Source Title	Materials Science
Source citation (APA Format)	Jankauskaite, V., Abzalbekuly, B., Lisauskaite, A., Procycevas, I., Fataraite, E., Vitkauskiene, A., & Janakhmetov, U. (2014). Silicone rubber and microcrystalline cellulose composites with antimicrobial properties. *Materials Science*, *20*(1), 42–49. https://doi.org/10.5755/j01.ms.20.1.4397
Original URL	https://www.researchgate.net/publication/274653893_Silicone_Rubber_and_Microcrystalline_Cellulose_Composites_with_Antimicrobial_Properties
Source type	Journal Article
Keywords	polydimethylsiloxane, microcrystalline cellulose, silver nanoparticles, structure, antibacterial properties, mechanical properties
#Tags	

Summary of key points + notes (include methodology)	It is important to develop materials that have mechanical strength and antimicrobial activity for medical and industrial applications. PDMS or silicone rubber is known for its flexibility and biocompatibility, but it lacks antimicrobial properties. To help with this, researchers created a composite of MCC particles integrated with silver nanoparticles into a PDMS matrix. The silver nanoparticles were synthesized directly on the surface of MCC using silver nitrate and sodium borohydride. The modified MCC/AgNPs was then mixed with PDMS to form the composite. Then, they evaluated the composite's microstructure, mechanical performance, and antibacterial properties. The results showed that AgNPs successfully bonded to MCC, and the composite had flexibility and strength. Higher AgNP content increased antibacterial activity, but the composite didn't have much of an effect on bacterial colonies after some time. The MCC/AgNPs as a filler combined with the PDMS as a matrix were found to bring multifunctional properties but the influence of silver concentration on mechanical behavior needs to be researched further.
	
	• Silicones: biocompatible and biodurable
	  ○ Polymers with skeletal backbone made of silicon-oxygen bonds
	  ○ Most common member of siloxane group if polydimethylsiloxane (PDMS)
	• PDMS had low surface energy, good insulation, high permeability to gases but has poor mechanical properties
	  ○ To overcome this, reinforcing fillers are used
	• MCC particles are inherently stiff and reinforce various polymer matrixes such as PDMS
	• The key of Ag toxicity is the amount of Ag+ ions that are released

	• MCC is purified, partially depolymerized cellulose that was prepared by treated a-cellulose with mineral acids
	• Getting silver nanoparticles:
	  ○ Dissolved to split in Ag+ and NO3-
	  ○ To turn silver ions into solid silver, ions are reduced by receiving an electron from a donor which in this case was sodium borohydride
	• To make the MCC/AgNPs
	  ○ MCC was placed in DI water and stirred
	  ○ PVP (stabilizer) and silver nitrate added and stirred
	  ○ Sodium borohydride added→changed color to yellow
	  ○ Use vacuum and dry final material
	• PDMS samples prepped by:
	  ○ Mixing MCC with vinyl functional silicone and sonifying for 10min
	  ○ Blending vinyl functional siloxane and hydbrid functional crosslinker at a 1:1 ratio
	  ○ Putting uncured mixture under vacuum to rid of bubbles
	  ○ Pouring liquid mixture in mold and curing silicone by putting molds in oven
	• Nanoparticle size on the MCC/AgNP composites ranges from 25-85 nm
	• Voids were noticed around some MCC particles, indicating poor adhesion between PDMS and MCC
	• Antimicrobial activity is not very strong---after longer times of incubation, bacteria colonies started to grow and multiply
	• Increased MCC content increases tensile strength, elongation of break, and Shore A hardness
	• MCC increases compression resistance of PDMS

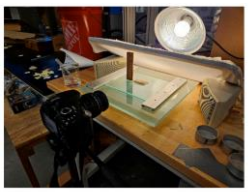
Research Question/Problem/ Need	How can polydimethylsiloxane (PDMS) and microcrystalline cellulose (MCC) be combined to create composites with high mechanical properties and antimicrobial activity?
Important Figures	
VOCAB: (w/definition)	In situ: research performed directly within the natural environment/organism's original location Sonifying: using ultrasonic sound waves to mix or disperse materials more effectively
Cited references to follow up on	Laka, M., Chernyavskaya, S., Shulga, G., Shapovalov, V., Valenkov, A.,

	Tavroginskaya, M. Use of CelluloseContaining Fillers in Composites with Polypropylene Materials Science (Medžiagotyra) 17 (2) 2011: pp. 150 – 154. Zugenmaier, P. Materials of Cellulose Derivatives and Fiber-Reinforced Cellulose–Polypropylene Composites: Characterization and Application Pure and Applied Chemistry 78 (10) 2006: pp. 1843 – 1855.
Follow up Questions	• What's the advantage of using in situ synthesis of AgNPs? • Can other antimicrobial compounds be used instead of silver nanoparticles to improve the effect?

Article #15 Notes: Finer Measurement Scales for Induced Hydrophobicity Using the Water Droplet Penetration Test

Source Title	geotechnics
Source citation (APA Format)	Veneris, M., & Farid, A. (2024). Finer measurement scales for induced hydrophobicity using the water droplet penetration test. *Geotechnics*, *4*(2), 581–603. https://doi.org/10.3390/geotechnics4020032
Original URL	https://www.mdpi.com/2673-7094/4/2/32
Source type	Journal article
Keywords	hydrophobicity; soil water repellency; SWR; wildfires; burned soil; sorptivity; infiltration; WDPT
#Tags	
Summary of key points + notes (include methodology)	This article addresses the problem that the water drop penetration test (WDPT), commonly used to diagnose hydrophobic soil, depends on one factor (time) and doesn't account for variables such as soil grain size or particle size. This limits its ability to classify hydrophobic soil across different soil types. The authors set up controlled sand beds of 3 grain sizes (coarse, medium, fine) which were treated with varying concentrations of a hydrophobic surrogate. Then, each type of soil had WDPT tests conducted on them, and height, contact angle, and droplet penetration over time were measured through imaging. Their findings show that droplet penetration is split into 2 regimes. The first is regime 1, where infiltration occurs at a steady rate, and there is no particle lift. The second, regime 2, occurs when early particle lift delays penetration rate and reduces sorptivity. Additionally, they found that sorptivity for coarse grains at high hydrophobicity was like medium grains at intermediate hydrophobicity or fine grains at lower hydrophobicity, revealing that grain size influences WDPT results. Therefore, they concluded that for increased accuracy, WDPT should be calibrated to grain size. • Soil hydrophobicity is commonly seen in the upper layers of soil • Wildfires cause soil hydrophobicity by changing surface chemistry of soil particles from particles coated with naturally organic hydrophobic compound • Techniques for classifying hydrophobicity is still developing • The Water droplet Penetration Test (WDPT) is a common way to roughly measure hydrophobicity → contact angle and other methods may be more accurate • WDPT does not account for many variables such as particle lift, other soil properties, grain size • Some hydrophobic soil can show hydrophilic tendencies when some % of moisture by weight is added to it

	• Soil water repellency is commonly present in the 1in of the scorched surface
	• Common fire-induced hydrophobicity is seen between 2-10cm
	• Droplets on hydrophobic soil ball up into marble-like shapes, often covered by soil particle
	• According to Young's law, particles tend to attach to the air-water interface where it's energetically favorable
	• To create a controlled hydrophobic environment, different levels of a liquid repellent elastomer was using and mixed into sand samples
	  ○ Nikwax Wax Cotto-proof TM (dilutions of 0.6%-0.8%)
	• Water droplets were placed on top of sand beds with a pipette ~2mm above sand bed
	• Images and videos were taken through a Canon Camera which obtained the entire infiltration process→video stopped when droplets dropped in height by 0.1mm+ or when it had been 5 min
	• Right and left-hand contact angles were recorded, and the avg was reported
	• The end times are when there was no more movement observed in the water droplet or grain movement
	• Grain size affects contact angle and WDPT time
	• WDPT times varied significantly, even when concentration of hydrophobicity causing product and grain size were maintained
	• Large variation among sorptivity values for the 16 drops in each environment
	• If there is considerable particle lift the time rate of water penetration will be slower/smaller
	  ○ If hydrophobic particle is lifted, air pockets form beneath, slowing flow
	• When hydrophobicity increases, the tendency for particle lift and soil covering the droplet increased
	• Coarse soil shows higher particle lift because of their larger particle sizes while fine-grained soils are less affected
	• Two different regimes: Regime 1 is when there's no particle lift; regime 2 Is when there is particle lift that delays WDPT
	• For higher level analysis of hydrophobicity in soil, WDPT must be calibrates based on grain sizes

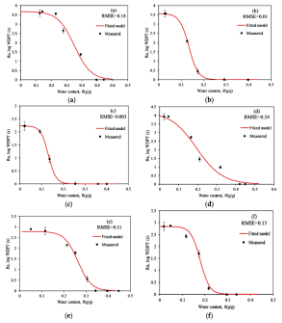
Research Question/Problem/ Need	How can the water droplet penetration test (WDPT) be improved to provide finer measurements of induced soil hydrophobicity, especially accounting for factors such as grain size and particle lift?
Important Figures	 Figure 1. Experimental setup for imaging WDPTs, including height and contact angle.  **Figure 10.** From left to right, droplets are assigned a value of 0% (or negligible), 50%, 75%, and 100% for particle lift.

VOCAB: (w/definition)	Sorptivity: a measure of a material's capacity to absorb and transmit fluids, such as water, through capillary action Surrogate: a substitute or stand in Polynomial Fit: the process of finding a polynomial function that best represents a set of data points, especially when the underlying relationship is non-linear
Cited references to follow up on	Letey, J.; Osborn, J.; Pelishek, R.E. The Influence of the Water-Solid Contact Angle on Water Movement in Soil. Int. Assoc. Sci. Hydrol. Bull. 1962, 7, 75–81. [CrossRef] Pardini, G.; Gispert, M.; Dunjo, G. Relative Influence of Wildfire on Soil Properties and Erosion Processes in Different Mediterranean Environments in NE Spain. Sci. Total Environ. 2004, 328, 237–246. [CrossRef] [PubMed]
Follow up Questions	• How would classification based on time using WDPT test change based on Regime 1 vs 2? • Why wasn't a higher level of hydrophobicity induced in the soil? • What would happen if the soil isn't level before conducting the WDPT test?

Article #16 Notes: The Relationship between Soil Moisture and Soil Water Repellency Persistence in Hydrophobic Soils

Source Title	water
Source citation (APA Format)	Bayad, M., Chau, H. W., Trolove, S., Moir, J., Condron, L., & Bouray, M. (2020). The relationship between soil moisture and soil water repellency persistence in hydrophobic soils. *Water, 12*(9), 2322. https://doi.org/10.3390/w12092322
Original URL	https://www.mdpi.com/2073-4441/12/9/2322
Source type	Journal Article
Keywords	soil water repellency; soil moisture; soil carbon; soil texture
#Tags	
Summary of key points + notes (include methodology)	This study addresses the problem that while soil water repellency (SWR) is well studied, the persistence of repellency is not as researched. Researchers measured SWR persistence in 10 naturally hydrophobic soils as moisture content decreased and fitted a unique sigmoidal equation relating actual persistence (Ra) to soil moisture (theta), potential persistence (Rp), and two shape parameters (theta c and delta). They then examined how soil properties such as carbon content, soil texture, and specific surface area relate to these parameters. Findings reveal 3 persistence vs moisture patterns depending on theta c and delta, and found a strong correlation between carbon content and theta c. They demonstrated that soil texture and surface area influence the maximum persistence of water repellency. This model is useful for predicting how SWR develops during drying in hydrophobic soils. • Theorized that soils express water repellency when moisture content drops below a certain amount • The severity of SWR can be estimated through ethanol drop, CA and the persistence through WDPT • SWR depends on soil moisture (theta)—expressed as SWR characteristic curve • Most prior research focuses on SWR severity vs moisture not SWR persistence dynamic • Some soils show rapid decrease in contact angle with increasing theta—lower repellency • Others show slow decrease---more repellency

	• MED and CA can measure initial hydrophobic strength/severity not how it changes over time
	• Sandy soils are more likely to become hydrophobic due to their low surface area
	• Potential SWR= max level of water repellency of a soil when it's completely dry
	• Measurements of SWR persistence show sigmoidal response to decreasing theta in hydrophobic soil
	• SWR persistence and severity were measured on 9 soil samples from nine sites representing 4 soil orders
	• Water repellency persistence vs water content were recorded on 10 hydrophobic soils
	• Measurement of SWR persistence (Ra):
	  ○ Soil saturated and air dried
	  ○ 5 replicates tested for each moisture level
	  ○ 40 ul of DI water placed on soil surface
	  ○ WDPT time recorded
	  ○ Measurements taken on moisture content levels, reduce ~10% each time
	  ○ When moisture stabilized at its minimum, samples were oven-dried to determine dry weight
	• SWR severity: measured through MED method
	  ○ Ethanol solutions of different concentrations were prepped and placed on each soil surface
	  ○ The MED value corresponded to the lowest ethanol concentration that penetrated the soil within 5s, indicating SWR severity
	• They developed a math model to describe how SWR persistence changes with soil moisture
	  ○ Ra=actual SWR persistence
	  ○ Rp=potential SWR PERSISTENCE
	  ○ THETA=GRAVIMETRIC SOIL MOISTURE CONTENT
	  ○ Theta c=critical soil moisture content (when repellency starts rapidly increasing)
	  ○ Delta=steepness parameter
	• Observed data (log WDPT) were compared to fitted model values
	• Accuracy evaluated using root mean square error
	• Best fitting parameters were those that minimized RMSE—model matched real data
	• They also estimated how much particle surface area each soil had
	• WDPT increased significantly with decreasing soil moisture
	• Data showed that SWR persistence curve was sigmoidal for sand samples but unimodal for loam, clay loam, and slit loam samples
	• From the sigmoidal curves, 3 phases were observed:
	  ○ Wettable phase where hydrophobic compounds detach from soil minerals

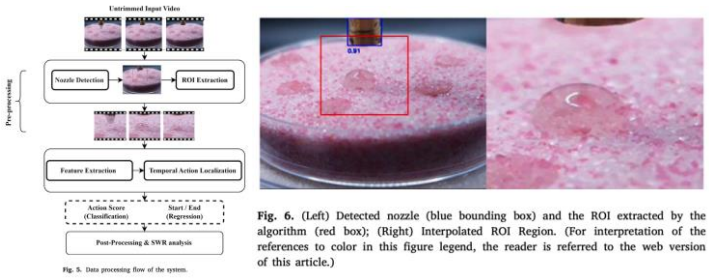
	○ Transition phase, which is when exposure of mineral surfaces corresponds to attachment of hydrophobic compounds ○ Saturation phase—coating of soil minerals that is limited by the saturation of available surface area and amt of hydrophobic compounds • The max hydrophobicity of soil doesn't determine exact moisture level where it becomes critically water repellent during drying • Soils richer in hydrophobic organic matter remain repellent at higher water contents • Soil texture and C controls potential SWR (Rp) • The equation made models Ra as soil dries using Rp, theta c (max persistence when dry) and delta (steepness/smoothness of transition) • Pattern 1: low theta c and high delta ○ Soil resists developing SWR early, but SWR increases suddenly near theta c • Pattern 2: high theta c and low delta ○ Soils start developing repellency early • Pattern 3 high theta c and delta ○ Persistent repellency develops suddenly in early drying
Research Question/Problem/ Need	How can soil moisture content's influence on the persistence of soil water repellency in hydrophobic soils be modelled?
Important Figures	Ra= actual persistence of SWR by log WDPT 
VOCAB: (w/definition)	Sigmoidal: shaped like the letter S Unimodal: a distribution with a single peak
Cited references to follow up on	Franco, C.M.M.; Clarke, P.J.; Tate, M.E.; Oades, J.M. Chapter 4—Chemical characterisation of water repellent materials in Australian sands. In Soil Water Repellency; Elsevier: Amsterdam, The Netherlands, 2003; pp. 37–48. ISBN 978-0-444-51269-7. Doerr, S.H. On standardizing the 'Water Drop Penetration Time' and the 'Molarity of an Ethanol Droplet' techniques to classify soil hydrophobicity: A case study using medium textured soils. Earth Surf. Process. Landf. 1998, 23,

	663–668. [CrossRef]
Follow up Questions	• How does actual SWR persistence differ from potential SWR in field soils practically? • Does theta c's strong correlation with soil carbon content change anything for managing hydrophobic soils?

Article #17 Notes: A machine learning framework to measure Water Drop Penetration Time (WDPT) for soil water repellency analysis

Source Title	Elsevier
Source citation (APA Format)	Wang, D., Regentova, E., Muthukumar, V., Berli, M., & Harris, F. C. (2024). A machine learning framework to measure Water Drop Penetration Time (WDPT) for soil water repellency analysis. *Machine Learning with Applications*, *18*, 100595. https://doi.org/10.1016/j.mlwa.2024.100595
Original URL	https://www.sciencedirect.com/science/article/pii/S2666827024000719
Source type	Journal Article
Keywords	Temporal Action Localization, ActionFormer, TriDet, Water Drop Penetration Time (WDPT), Soil water repellency (SWR)
#Tags	
Summary of key points + notes (include methodology)	The article addresses the challenge of accurately and easily measuring WDPT, a method of characterizing soil water repellency. Manual WDPT measurements are time-consuming and prone to human error, especially for hydrophobic soils where absorption occurs slowly, and visual changes are subtle. To solve this, the researchers created a machine learning-based video analysis framework that automatically detects key events (drop landing, bouncing, absorption) from video recordings. The system uses computer vision and feature extraction and includes spatial and temporal information to compute WDPT precisely. The process includes video capture of the droplet and soil, feature extraction, action detection through TAL models, and finally WDPT calculation. They validated the model against manual measurements and found that it had good accuracy. • The most common method to measure SWR is the WDPT test (in field or lab) • In lab, they do 5 drops of DI water and take the median value • These manual measurements are time-consuming and can have human inconsistencies • Anchor-based models use predefined reference points or time segments representing action's start/end times • Anchor-free models search for the action in the video, going through each frame ○ Accurate but time demanding for longer videos • A backbone is a feature extractor: it processes raw videos and

	produces useful feature representations
	  ○ Reduces computational cost and improves accuracy
	• 13D is one of the well-known backbones: it learns what happens/appearance and how it changes over time/motion
	• VideoMAE V2 is a modern transformer backbone
	• ActionFormer and TriDet showed the highest performance (anchor-free models)
	• Used quartz sand and hydrochloric acid to create soil samples with varying repellency
	• The sand was dyed and sprayed with Scotchgard
	• Acid washed sand was 0% repellent and dyed/Scotchgard sand was 100% repellent
	• A black background was placed behind water for high contrast
	• **Nozzle to soil height is 7mm to minimize gravity**
	• They recorded 140 high frame rate (90fps) video clips of various SWR level soils, with most clips containing 6750 frames
	• Clips were recorded at various camera positions so that the optical axis is within a 15-degree angle with respect to soil surface
	• Each video was labeled with start and end frames of the WDPT and used to train machine learning models
	• The system is designed to extract a region of interest (ROI) from every frame
	• The nozzle is detected and used as reference for this
	• Video is then processed by a ML model to extract spatial and temporal features. These features are combined into 1 for a unified feature representation
	• The TAL takes these features and identifies key moments of interest (when drop lands, when it bounces, when its absorbed)
	• For post-processing, NMS is used to remove duplicate detections and keep the most accurate prediction
	• SWR level is determined based on WDPT and time interval
	• Their baseline included the pre-trained 2 stream 13D, full-frame processing, data augmentation, and TAL using ActionFormer
	• YOLOv9 is a LM that is used to detect objects and it uses Programmable Gradient Info (PGI) to produce accurate and informative gradients
	• They trained and tested YOLOv9 on 1000 frames from the various clips of recorded videos
	• Out of the 640 x 480 pixel frame size, the ROI was 240 x 240 and hey used bicubic interpolation to enlarge ROIs to the 640 x 480 pixel frame size
	• 13D framework was found to have the best precision for feature extraction
	• Use RAFT to compute dense optical flow or the motion of each pixel between frames
	  ○ When soil is highly hydrophobic, water absorbs slowly and the motion between frames becomes tiny and RAFT can detect

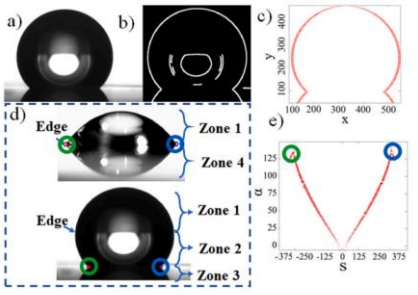
	those differences ○ Builds predictions of motion by repeatedly checking pixel correspondence across frames • 16 frame stacks had the best performance for baselines model • Fed TAL models 140 clips, 60 were used for the data for training • Augmentation includes grayscale intensities, added noises, altered intensity levels to mitigate overfitting • Used Recall, which measures proportion of correctly detected actions by the model, to evaluate WDPT performance • The ActionFormer outperforms the TriDet model by average AP and characterization accuracy of soil repellency
Research Question/Problem/ Need	How can the WDPT test be automated using TAL models to characterize soil repellency?
Important Figures	 Fig. 5. Data processing flow of the system. **Fig. 6.** (Left) Detected nozzle (blue bounding box) and the ROI extracted by the algorithm (red box); (Right) Interpolated ROI Region. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
VOCAB: (w/definition)	TAL: a computer vision task that involves identifying the start and end time, as well as the category, of all actions within an untrimmed video Overfitting: when a ML model learns its training data too well, capturing noise/specific details instead of general patterns
Cited references to follow up on	Mayer, N., Ilg, E., Hausser, P., Fischer, P., Cremers, D., Dosovitskiy, A., & Brox, T. (2016). A large dataset to train convolutional networks for disparity, optical flow, and scene flow estimation. In 2016 IEEE conference on computer vision and pattern recognition. CVPR, IEEE, http://dx.doi.org/10.1109/cvpr.2016.438. Liu, X., Wang, Q., Hu, Y., Tang, X., Zhang, S., Bai, S., & Bai, X. (2022). End-to-end temporal action detection with transformer. IEEE Transactions on Image Processing, 31, 5427–5441. http://dx.doi.org/10.1109/tip.2022.3195321, URL http://dx.doi. org/10.1109/TIP.2022.3195321. Publisher: Institute of Electrical and Electronics Engineers (IEEE).
Follow up Questions	• How are the frames labeled and fed into the ML models? • Would the methodology be similar for identifying contact angles?

Article #18 Notes: Contact angle measurements: From existing methods to an open-source tool

Source Title	Elsevier
Source citation (APA Format)	Akbari, R., & Antonini, C. (2021). Contact angle measurements: From existing methods to an open-source tool. *Advances in Colloid and Interface Science*, *294*, 102470. https://doi.org/10.1016/j.cis.2021.102470
Original URL	https://www.sciencedirect.com/science/article/abs/pii/S0001868621001111
Source type	Journal Article
Keywords	Wetting, Contact angle, Image analysis, MATLAB, Dropen, Open-source
#Tags	
Summary of key points + notes (include methodology)	This study addresses the problem of accurately identifying contact angle and measuring them from drop profile images. The authors evaluate and refine automatic image-analysis techniques based on mask methods, specifically circle, triangle, and fuzzy interface masks. These approaches estimate the local slope along the drop profile through the convolution between the image intensity matrix and special designed masks, automating detection of the contact point. The authors integrate these methods into an open-source application, Dropen, and assess its performance using virtual drops with known contact angles and real images. They compare manual and automatic contact point identification, and evaluate multiple fitting techniques (circle, polynomial, DropSnake, LB-ADSA) and analyze theta errors. In virtual drops, the automatic masks proved to have better accuracy than manual selection but show weakness around theta of 90 degrees or less than 50 degrees. This limitation is less impactful in real images, however. The circle mask method seemed to be the most reliable contact point identification, especially compared to the other mask methods. Compared to common fitting methods, the circle mask achieves similar accuracy with the bonus of being automated. Overall, the study finds that mask-based contact point identification offers a good alternative to manual or fitting methods if good imaging practices are maintained. • The concept of using contact angles for water droplets on the surface was proposed by Thomas Young in 1805 • His equation assumes the solid surface to be ideal • Wenzel developed an equation to address surface roughness and Cassie and Bater created another equation to describe composite wetting conditions • These do not account for the multiple values of contact angle due to hysteresis • Therefore, to characterize a surface, the advancing and receding contact

	angles are measured by changing the volume of a drop on a surface • Cameras to capture images can be diverse—CCD and CMOS sensors with typical resolutions of 2-50 um/px or 20-500 ppm • Ways to measure contact angle: measure by aligning a tangent line, the fitting method using Young-Laplace equation, and the mask method • Image analysis is often conducted using a proprietary software or development of own code ○ Exceptions are DropSnake and LB-ADSA which are plug-ins in ImageJ • They will assess existing image processing method for contact angle measurements using a novel open-source software, Dropen • Tangent line method is not very accurate • Young-Laplace equation relates changes in pressures across the drop profile, including hydrostatic and curvature-induced pressures to the radii of the curvature and the surface tension • Young-Laplace cannot be used for non-symmetric drops, making circle and polynomial fittings a better alternative for local profile fitting in proximity of the contact point • In circle fitting, a circle is fitted to the drop profile • Polynomial fitting is similar but uses a polynomial of order to fit the drop-profile using the least-squares method • The mask method doesn't require profile fitting and is inspired by the goniometer tool • A mask is a 2D cubic matrix of size m x m • Each element of the mask matrix has a defined intensity based on its shape • The mask is laid on a black and white img of the drop where 0= liquid and 1=air/background • The mask is convoluted over the drop profile image and at each point along the drop contour, the convolution multiplies mask values with corresponding image pixels • By analyzing the zero elements, the local slope of the drop can be determined • Once the contact point is located, the contact angle is just the slope at that point • Mask method can detect contact point automatically and is good for superhydrophobic surfaces • Imadjust and Zerocross are found to be the most effective functions to adjust image resolution and edge data detection • First, the input image is analyzed using the Zerocross method • Then the profile data is extracted using the 'bwboundaries' function • Then more information is determined using the profile data to divide the image into 4 zones • Then local slopes are computed • Then the max local slopes on the right and left are found and their slope is = to the contact angle values

	• Virtual and real drops are used to evaluate the accuracy of each method
	• Two different methods are used to identify contact points—manual and automatic
	• Contact pt:
	  ○ Automatic: circle (CM), triangle(TM), fuzzy interface masks(FIM)
	• Contact angle:
	  ○ Circle, polynomial fitting
	  ○ Dropen, referenced with DropSnake & LB-ADSA
	• Contact pt results:
	  ○ Manual:
	  ▪ Error is random across contact angles which indicates human measurement variability
	  ○ Auto:
	  ▪ Circle&triangle: has failure when theta is around 90 or less than 50 and issues mostly appear in virtual drops rather than real images
	  ▪ Fuzzy: slightly higher computational cost and no clear accuracy improvement
	• The error in polynomial fitting is similar to dropsnake and lb-adsa and is 4x larger than circle fitting
	• The fuzzy method fails to evaluate contact pts and angles of virtual drops in comparison to the triangle and circle methods
	• The automatic CM method works as good as circle and polynomial fitting approaches, w/ advantage of being fully automcatic
	• Image quality determines edge detection, the sample and camera should be placed horizontally, good light exposure, good resolution images
	• In virtual drops, automated CM does better than manual selection
	• Errors in contact pt in TM and FIM are larger than CM
	• The error in CM is due to the local curvature of the drop profile

Research Question/Problem/ Need	Can contact point identification and contact angle measurement in drop profile be fully automated by using mask-base methods and how do these compare to traditional fitting and manual approaches?
Important Figures	 **Fig. 3.** a) raw drop image, b) edge detection, c) extracted profile data, d) strategy of defining various zones in hydrophilic and hydrophobic drops, and e) measuring local slopes using the mask method. Green and blue squares demonstrate to the maximum local slopes and consequently, the left and right contact points, respectively. $\theta_{left} = 135°$, and $\theta_{right} = 140.2°$.(For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

VOCAB: (w/definition)	Hysteresis: a phenomenon where the output of a system depends on its history, causing a "lag" in response to a changing input Proprietary: belonging to a private owner Least-squares method: a statistical technique used to find the best-fitting line or curve for a set of data points
Cited references to follow up on	Kwok DY, Neumann AW. Contact angle measurement and contact angle interpretation. Adv Colloid Interface Sci 1999;81:167–249. Korhonen JT, Huhtamaki ¨ T, Ikkala O, Ras RHA. Reliable measurement of the receding contact angle. Langmuir 2013;29:3858–63.
Follow up Questions	• Can mask method be adapted to handle very asymmetric drops? • How would alternative mask shapes change accuracy? (elliptical for example)

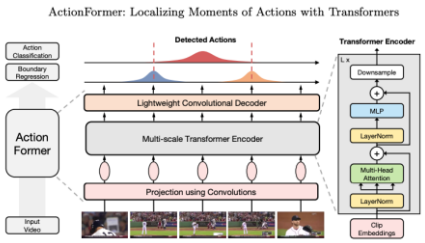
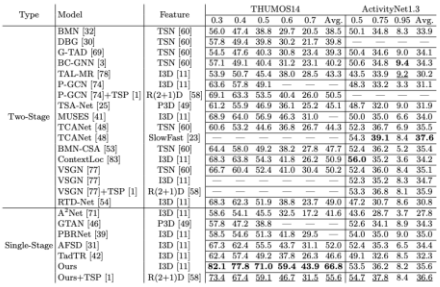
Article #19 Notes: ActionFormer: Localizing Moments of Actions with Transformers

Source Title	ECVA
Source citation (APA Format)	Zhang, C.-L., Wu, J., & Li, Y. (n.d.). *ActionFormer: Localizing Moments of Actions with Transformers*. https://www.ecva.net/papers/eccv_2022/papers_ECCV/papers/136640485.pdf
Original URL	https://www.ecva.net/papers/eccv_2022/papers_ECCV/papers/136640485.pdf
Source type	Paper/article
Keywords	temporal action localization; action recognition; egocentric vision; vision transformers; video understanding
#Tags	

Summary of key points + notes (include methodology)	This paper addresses the challenge of temporal action localization (TAL) in videos, or the problem of identifying start/end times of actions and heir categories in untrimmed videos. The authors create ActionFormer, a Transformer-based single-stage model that avoids action proposals and anchor windows by classifying every time step and determining distances of each moment to the start/end times of an action. Using a multiscale temporal feature pyramid with local self-attention and a convolutional decoder, ActionFormer obtains great results with a 71% mAP on THUMOS14, and strong results on ActivityNet-1.3 and EPIC-Kitchens 100 datasets. Ablation studies show the effectiveness of the Transformer encoder and design choices, showing that the Transformer approach can advance TAL performance.
	
	• Made a Transformer based model for TAL
	• Transformers use self-attention, used for capturing long-range dependencies in sequences
	  ○ Good for untrimmed videos
	• This model uses local self-attention by focusing on relevant temporal context
	• Classifies every moment in the video
	• Regresses action boundaries (start/end times of action)
	• Can localize actions in a single shot
	  ○ No proposals, predefines anchor windows
	  ○ Model is simpler and faster
	• Its local self-attention produces a feature pyramid (multi-scale representation of the video over time)
	• Each point in the feature pyramid corresponds to a moment in the video and is treated as a potential action candidate

	• It uses a convolutional decoder and classifies it (what part of an action) and regression (how far the moment is from action start and end)
	• This regression allows the model to compute start/end times
	• This design surpasses previous works by significant margins
	• ActionFormer treats a video as a sequence of small clips with a feature vector xt that describes what's happening at that moment
	• The video is $X=\{x1,x2,\ldots,xT\}$ where T is how many clips are there
	• The ground-truth actions are $Y=\{y1,y2,\ldots,yN\}$, where each action $y_i = (s_i, e_i, a_i)$ has a start time si and end time ei and a class label ai
	• The video is still $\{x1,\ldots,xT\}$ but now the model outputs one prediction $y\hat{}_t$ for every time step t
	• Encoding videos with Transformer
	  ○ Their model encodes an input video X into a multiscale feature representation Z using an encoder g
	  ○ g consists of a projection function that embeds each xt into a D-dimensional space and a Transformers network that maps the features to the output feature pyramid Z
	  ○ for each position t it compares its feature to every other position and if they are similar, the similarity score is higher
	  ○ their Transformers has L Transformer layer with each layer having alternating layers of local multiheaded self attention (MSA)
	• Then the model decodes the feature pyramid Z from encoder g using decoder h
	  ○ Examines each moment t and predicts probability of action at every moment t
	  ○ The regression head examines every moment r and predicts distances to the beginning and end of an action
	• At every time step, the model is punished if it classifies incorrectly
	• At only the time steps inside real actions, it's punished if its predicted start/end distances are off
	• These 2 penalties are added up, averaged, and that's the training loss for that video
	• Their method achieves an average mAP of 66.8% on THUMOS14 (video dataset used to evaluate TAL models) and outperforms all previous methods
	• Results on ActivityNet-1.3 (another dataset): avg mAP = 35.6%
	• Results on EPIC-Kitchens 100 (cooking dataset): had higher mAP than BMN and G-TAD
	• They used ablations to determine that replacing a 1D convolutional encoder with their Transformer included increases the average mAP
	• Removing the feature pyramid results in a huge performance drop

Research Question/Problem/ Need	Can a single stage Transformer model accurately find when actions happen in long videos and what they are, without using proposals or anchors, and do it better

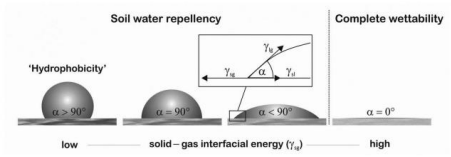
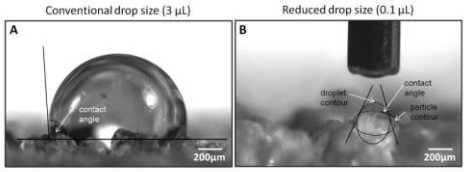
	than existing methods?
Important Figures	 
VOCAB: (w/definition)	mAP: machine average precision, a metric in CV for evaluating object detection models action proposal: two-step approach where model first guesses where actions may be and then decides what actions they are anchor windows: pre-defined temporal segments placed along video timeline and at each position, the model tries to match 1+ anchor window to real actionsfoll transformer: a type of neural network structure that processes sequential data like text using self-attention to understand the relationships between different parts of the input ablation: taking pieces out of the model to see what really matters
Cited references to follow up on	Dosovitskiy, A., Beyer, L., Kolesnikov, A., Weissenborn, D., Zhai, X., Unterthiner, T., Dehghani, M., Minderer, M., Heigold, G., Gelly, S., et al.: An image is worth 16x16 words: Transformers for image recognition at scale. In: Int. Conf. Learn. Represent. (2021) Lin, T., Zhao, X., Shou, Z.: Single shot temporal action detection. In: ACM Int. Conf. Multimedia. pp. 988–996 (2017)
Follow up Questions	• Are there any action types or video conditions where this model starts to have issues? • How does it handle unclear action transitions?

Article #20 Notes: Small-scale contact angle mapping on undisturbed soil surfaces

Source Title	Paradigm
Source citation (APA Format)	Bachmann, J., Goebel, M., & Woche, S. K. (2013). Small-scale contact angle mapping on undisturbed soil surfaces. *Journal of Hydrology and Hydromechanics*, *61*(1), 3–8. https://doi.org/10.2478/johh-2013-0002
Original URL	https://reference-global.com/article/10.2478/johh-2013-0002
Source type	Journal Article
Keywords	Hydrophobicity; Sessile drop method; Soil water repellency; Water drop penetration time; Wettability
#Tags	

Summary of key points + notes (include methodology)	This paper addresses the issue that soils often show varying levels of water repellency, meaning they aren't fully wettable or completely hydrophobic. To study this, researchers introduced a technique where they take tiny water droplets (1 uL) and directly measure the contact angle on undisturbed soil surfaces to preserve the soil's natural spatial arrangement. Using these small-scale measurements and analysis, they reveal spatial variations in soil wettability that conventional tests like WDPT cannot detect. These fine differences in wettability explain how water moves through the soil. The study ultimately shows that their small-scale contact angle mapping method can demonstrate hydrophobicity patterns important for understanding soil water behavior.
	
	• This study developed a high-resolution contact-angle method that can measure water repellency at the millimeter scale, showing small variations that other tests miss and they show how these can affect how water flows through soil
	• SWR is caused by low surface free energy→weak attraction to liquids
	• CA is formed at the three-phase (solid-liquid-gas) contact line
	• Young's equation describes the CA: cos α= (γsv – γsl)/ γlv
	  ○ γ (surface free energy)
	  ○ sv- between solid and vapor, sl-between liquid and solid, lv-between liquid and vapor
	  ○ α contact angle
	• CA>90 indicates hydrophobicity
	• Studies have shown that soils are neither completely wettable nor hydrophobic, but have a subcritical level of SWR
	• Non-polar organic matter on soil particles causes hydrophobic surfaces
	• Long-chain amphiphilic organic compounds from plants, microbes, or fungi can induce soil hydrophobicity

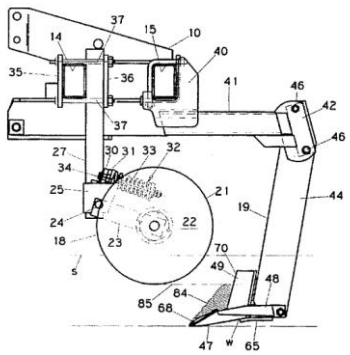
- When wet, compounds are usually hydrophilic but when dry, polar ends bond to each other or the particles, so that hydrophobic groups face pore space
- Sources: root mucilage, plant leaves, bacterial exudates, fungal mycelia and exudates
- SWR makes water move unevenly through the soil
- Soil usually holds water between field capacity or when it's wet enough for plants and wilting point or when plants cannot get water
- Water forms tiny thin films around soil particles
- Even a little SWR can break up the continuous water paths
- Variability occurs because organic matter coasts soil particles differently
- This is important but there are rarely any studies of SWR at this tiny scale
- CA is usually determined on small amounts of dry and homogenized material, but a study showed that homogenizing the soil can affect CA
- This study's goals:
    - To find a prepping technique that preserves spatial arrangement of the grains
    - Characterize soil wettability using CA at high spatial resolution
    - Compare the small scale CA with those determined with the conventional approach with homogenized material
- Getting soil for experiment:
    - Got 2 steel cylinders (cores) that were pushed into the soil
    - They used a thin wire to slice the cores, giving clean surfaces for measurement
    - They dried the soil cylinders at 40 C until weight stopped changing
        - So moisture doesn't interfere with measurements
- The usual method: take a thin layer of soil and stick it to a glass slide with double-sided tape
- The researchers wanted to no disturb the soil they stuck the double sided tape to flexible tissue and pressed tissue gently to the surface of the soil cores so that the grains are picked up at their original positions
- To compare, they also homogenized soil to do the normal CA test
- Their soil had uneven organic matter distribution
- Small scale CA ranged fro, 47 to 140 and larger CA was found in the darker regions
- Mean CA ~82 and median ~81 so the distribution is roughly normal
- Conventional CA: brighter areas: 84, darker: 87
- Brighter areas: WDPT<5s and darker areas WDPT=8s
- Their technique is able to determine differences in the wetting properties at high resolution
- SWR in the subcritical domain cannot be determined or distinguished with the WDPT test
- In Sample 2:
    - Conventional: brighter 81.6 and darker 68
    - Single grain: brighter 22 and darker 38
    - There is a much lower CA than conventional

	○ Larger droplets average out the small scale hydrophobic spots ○ When a droplet land, water spreads horizontally and vertically to fill pores and then the remaining liquid forms a spherical shape
Research Question/Problem/ Need	How do small-scale differences in soil grains and organic matter affect water repellency, and how well do conventional tests capture these differences?
Important Figures	 **Fig. 1.** Schematic showing the contact angle (α) and its relationship to the interfacial energies (γ) of the three-phase (solid–liquid–gas) system (modified after Goebel et al., 2011).  **Fig. 4.** Comparison of drop size used for the conventional contact angle measurements on a layer of grains (3 µL drop volume) (A) and for contact angle measurements made on single grains (0.1 µL drop volume) (B). The baseline for conventional measurements is horizontal, for measurements on single grains the approximated contour line of the particle.
VOCAB: (w/definition)	Surface free energy: a measure of how "energetically attractive" a surface is to other substances (like water) Flocculation: the process where fine, suspended particles clump together to form larger masses called "flocs"
Cited references to follow up on	Bachmann, J., Woche, S.K., Goebel, M.O., Fischer, W.R., 2001. Contact angle and surface charge of wettable and hydrophobic silt particles. J. Soil Sci. Plant Nutr., 1, 26–33. Goebel, M.O., Bachmann, J., Woche, S.K., 2008. Modified technique to assess the wettability of soil aggregates: comparison with contact angles measured on crushed aggregates and bulk soil. Eur. J. Soil Sci., 59, 1241–1252.
Follow up Questions	• What scenarios is this method better than the usual CA method? • Are there types of soils where this method becomes less reliable?

Article #21 Notes: Primary tillage unit with reduced disturbance of surface soil and residue

Source Title	United States Patent Dietrich, Sr.
Source citation (APA Format)	Dietrich, W.J, Sr. (1996). *Primary tillage unit with reduced disturbance of surface soil and residue* (U.S. Patent No. 5,540,288). United States Patent and Trademark Office. https://image-ppubs.uspto.gov/dirsearch-public/print/downloadPdf/5540288
Original URL	https://image-ppubs.uspto.gov/dirsearch-public/print/downloadPdf/5540288
Source type	Patent
Keywords	Tillage, coulter, fracture zone, surface disturbance
#Tags	
Summary of key points + notes (include methodology)	This patent discusses the creation of a primary tillage unit for loosening subsurface soil while leaving surface soil and residue undisturbed, allowing for high-speed, low-disturbance deep tillage. Each unit included a coulter to cut a narrow slot, and a thing chisel slank aligned behind it, along with a shaped soil-working point that fractures soil upward into the slot. Rearward swept delta wings mounted above the point provide controlled vertical lift (around 2-2 in with an angle of 8-13) to extend the fracture zone from the side between the adjacent shanks, producing a continuous surface while preventing surface soil throwing. The design also has fins that move the loosened soil away from the shank, replaceable wings, and optional upward-bent tail sections for wet conditions. The overall system gives deep soil fracturing and porosity with minimal surface disturbance. • This conservation tillage unit fractures soil beneath the surface without throwing the surface soil and residue to the side • Soil erosion occurs from tilling the soil • Primary tillage (depth 6-10 in) is desirable to increase retention/absorption of water • Many farmers have changes to minimum tillage to reduce soil erosion • To reduce erosion, it's good to leave as much of previous crop residue on the surface • Chisel plows dig too deep and increase risks of erosion • Design of tillage: leading coulter (cuts narrow slot in soil) and a chisel plow shank behind it • Conventional chisel plows have a tapered wedge fron that throws soil • The improved design uses a narrow, vertical bar with a point and a delta-wing lift assembly behind and above • The tip cuts upward and outward which forms a fracture zone around and above

- The delta wings are swept-back lift surfaces
- Shark fin: fin-shaped piece mounted in front of the shank, and it splits the soil before the shank arrives
- Coulter cuts a narrow vertical slot and foes half the depth of the shank
- The point creates a forward fracture zone
- The shark fins further part the soil before the shank
- The delta wings lift and fracture soil just beside the shank
- The shank follows inside the coulter's pre-cut slot at the surface
- The combined action creates an uplift of the soil surface
- Coulter assembly
    - Round disc that cuts a narrow slot and is mounted on a pivoting support arm
    - A spring absorbs shock
    - It operates 3-5 in below soil surface
- Chisel plow
    - Shank: thin vertical bar that runs in the slot created by the coulter
- Point: metal top that sticks forward and downward
- Shark fin: small upright fun on top of the point
- Delta wings: 2 wing-shaped lifting plates on either side of the point
    - Controlled lifting
    - Hammock effect---slight concave rise of soil between shanks
- Soil behavior
    - Soil is fractured first, then gently lifting, allowing shank passage without heaving or blowing out soil
    - Surface soil and residue remain largely intact
    - Soil is left in larger clods than fine particles
- Delta wing: maintains gentle lift by limiting abrupt lift angles, keeping wings narrow, and positioning wings carefully relative to the shank
- Wing geometry
    - Downward ben: 35 degrees
    - Sweep-back: 72 degrees
    - Vertical soil lift: ~1in
- Soil moves over the wings
- Effective lift angle should be 8-13
- With a truncated wing version, a narrow strip-tillage can be achieved
- Claims:
- 1-lists the parts of the tiller unit
    - Each wing has lift angle <13 and vertical lift <2in
- 2-side plates mount forward on point and to the rear of the shank
- 3- shank has a notch forming an upward bearing surface
- 4- point includes an upward fin: leading edge, tapered side surfaces, rear surface adjacent to shank
- 6-a brace is welded beneath the point and supports the lower end of the shank
- 9-shank width <1 in and rearward swept wings have a leading edge angle >60 degrees

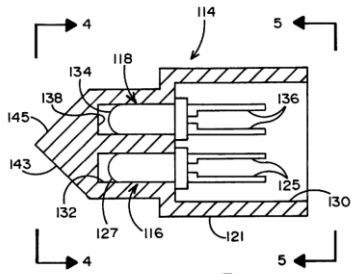
	• 10-operation at 4-7mph
Research Question/Problem/ Need	How can a tillage unit be made so that it leaves a narrow furrow without clearing surface reside and reducing the production of fine soils?
Important Figures	
VOCAB: (w/definition)	Fracture zone: area of soil that cracks because of plow Delta wings: small, triangular wing shaped plates on the chisel plow shank
Cited references to follow up on	Not cited in a way that I can know what the topic is
Follow up Questions	• How could the system be adjusted to work just as effectively at higher speeds? • What soil conditions was this tested on? • What component is the most helpful in minimizing soil disturbance?

Article #22 Notes: Automatic soil moisture sensing and watering system

Source Title	Google Patents
Source citation (APA Format)	Saarem, M. J. (1997, September 12). *US6079433A - Automatic soil moisture sensing and watering system - Google Patents*. Google.com. https://patents.google.com/patent/US6079433A/en
Original URL	https://patents.google.com/patent/US6079433A/en
Source type	Patent
Keywords	Sprinkler, moisture sensor, radiation, infrared
#Tags	
Summary of key points + notes (include methodology)	This invention proposes an inexpensive, soil-embedded moisture sensor that uses infrared light to measure soil moisture by how much light is reflected or transmitted through polished optical surfaces in contact with soil by a membrane. The preferred embodiment, the prism moisture sensor, uses 2 optically polished faces that provide high sensitivity by reflecting varying amounts of infrared light to a receiver based on how much water coats the surfaces. The controller interprets the sensor's voltage output, compared measurements over time, and uses both the absolute moisture level and rate of drying to automatically adjust irrigation timing and quantity. Testing showed the prism design offers better accuracy and stability compared to single-surface and bent-tube versions, making it the best configuration for maintaining soil moisture levels. • Automatic lawn sprinkler systems vary water application based on soil moisture • Traditional sprinklers water on a fixed schedule • Large lawns require zoned watering due to limited system pressure and flow • Over-watering or under-watering can occur • Existing moisture sensors are expensive, complex, inaccurate, or sensitive to soil conditions like salinity • Rain-detection systems only disable sprinklers during rainfall • Fixed-schedule systems don't account for humidity, light, differences I soil type, etc • The device measures the percentage of radiation transmitted/reflected which varies with soil moisture • It can provide multiple output levels or a continuous range for precise control • It can adjust watering timing or quantity automatically

	• Emits radiations→receives radiation→measures amount→compares with stored values→ determines watering treatment
	• Automatic moisture sensing and watering system:
	  ○ Components: moisture sensor, controller, porous membrane
	• Single-faced moisture sensor:
	  ○ Infrared transmitter and receiver inside housing
	  ○ Transmitter emits infrared light and some passes through to the soil
	  ○ The amount of light reflected to receiver depends on soil moisture (if more moist, more light will be transmitted and less reflected)
	• Prism moisture sensor:
	  ○ Infrared transmitter and receiver inside housing
	  ○ 2 optically polished surfaces to increase sensitivity
	  ○ Light from transmitter hits first polished surface, some transmitted and some reflected onto the second surface
	  ○ Then the light reaches the receiver and the percentage of light received correlates with moisture on both surfaces
	  ○ This has higher sensitivity
	• Bent tube moisture sensor
	  ○ Infrared transmitter and receiver connected through a bent tube
	  ○ Infrared light passes through bent tube and received light decreases as soil moisture increases
	  ○ Less sensitive than prism sensor but still functional
	• Testing:
	  ○ Sandy loam soil baked in containers
	  ○ 5 lbs of soil in each container with sensor places ~2.5in below
	  ○ Initial weight and output voltage recorded
	  ○ Water added incrementally until saturation
	  ○ 4 drying and watering cycles performed
	  ○ Prism sensor shows largest voltage swing—highest sensitivity
	  ○ Bent tube sensor is functional
	• Controller:
	  ○ Takes periodic readings from sensors
	  ○ Can calculate rate of change of soil moisture
	  ○ Adjusts watering start time, duration, or quantity based on data
	  ○ Algorithms can optimize for specific plants
	  ○ Can respond dynamically to fast soil moisture loss
	  ○ Can generate analog or digital output
	• The system tracks sensor voltage output over time, representing changes in soil moisture

Research Question/Problem/ Need	There is a need for an inexpensive, reliable, accurate soil moisture sensor for automatic irrigation

Important Figures	 FIG. 3
VOCAB: (w/definition)	Index of refraction: a measure of how much a material bends light passing through it
Cited references to follow up on	I couldn't find the citations
Follow up Questions	• What optical power and wavelength does the infrared transmitter use, and how sensitive is the receiver to wavelength changes? • What are the calibration steps?