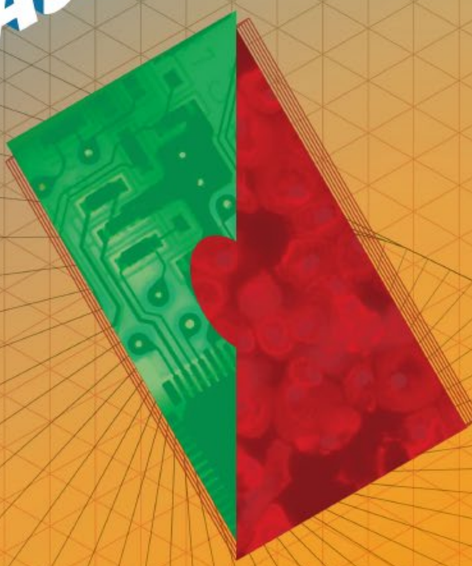
DREXEL UNIVERSITY
School of
Biomedical
Engineering, Science
and Health Systems

2019 SENIOR CELEBRATION AND SHOWCASE



Featuring Poster Presentations of
Life Saving Solutions
Addressing Unmet Medical Needs

2019
SENIOR CELEBRATION AND SHOWCASE

Thursday, May 30, 2018 – 5:00 PM

George D. Behrakis Grand Hall,
3210 Chestnut St. Philadelphia, PA 19104

(Inside Creese Student Center, on Chestnut Street, between 32nd and 33rd Streets.)

Program of Events

5:00 PM – 5:15 PM	**Showcase Event Registration**
5:15 PM – 5:25 PM	**Welcoming Remarks** *Paul W. Brandt-Rauf, Dean and Distinguished University Professor*
5:25 PM – 7:00 PM	**Poster Presentations, Judging, and Networking**
7:00 PM – 7:15 PM	**Awards Ceremony** *Andres Kriete, Associate Dean* *Wan Shih, Professor*
7:15 PM – 7:30 PM	**Concluding Remarks** *Paul W. Brandt-Rauf, Dean and Distinguished University Professor*

Quad Charts

Available online at **drexel.edu/biomed**

1	**Team 1**	A 3-D Flow System Device for Improved Production of Stabilized Ultrasound Contrast Agent Microbubbles
	Team 2	Mechanical Properties of a 3D Printed GelMA Scaffold
2	**Team 3**	Sensor Based Design for Monitoring of the Bone-Screw Interface
	Team 4	Rig for Simulating Post Surgery Assessments of Shoulder Joint Motion
3	**Team 5**	*In Vitro* Model of the Pancreatic Stroma for Drug Delivery Testing
	Team 6	3D Printed Palatal Obturators for Pediatric Cleft Palate Patients
4	**Team 7**	Tissue Phantom in Speed of Sound Lab
	Team 8	Mechanical Analysis of Prosthetic Suspension in Transfemoral Amputees
5	**Team 9**	Assistive Laboratory Device for Students Who Are Blind or Visually Impaired
	Team 10	Laryngoscope Cover for Pediatric Intubations
6	**Team 11**	Patient-Specific Alignment Device for Total Ankle Replacement
	Team 12	Design of Porous PEEK Topologies Using Fused Filament Fabrication
7	**Team 13**	Electro-acoustic Optimization of Ultrasonically Assisted Chronic Wound Healing Applicator
	Team 14	MXene Filter for Hemodialysate Regeneration
8	**Team 15**	Design of Optimized Detection Method of Breast Cancer Specific Molecule
	Team 16	Non-antibiotic Antimicrobial Coating for Urethral Catheter Application
9	**Team 17**	Deep Tissue Injury (DTI) Detection Using Piezoelectric Finger (PEF) Technology
	Team 18	Astronaut Hibernation Monitor
10	**Team 19**	Electromyogram Based Interface for Real-Time Tracking of Natural Limb Activity for Avatar Control in Virtual Environments
	Team 20	Mid-Fidelity Simulator Model for Training Cesarean Section in Kampala, Uganda
11	**Team 21**	Rhythmic Auditory Stimulation for the Enhancement of Declarative Memory
	Team 22	A Novel Micro-Fabricated Device for Non-Viral Transfection for Adoptive Cell Therapy Manufacturing
12	**Team 23**	Polarized Light Apparatus for Analyzing Collagen Structure Within Ligaments Under Load
	Team 24	3D Printed Bioresorbable Antibiotic Clip for Prevention of Spinal Surgical Site Infection
13	**Team 25**	Assistance Call Device for Advanced ALS Patients

TEAM **1**

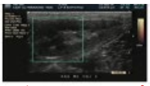
A 3-D Flow System Device for Improved Production of Stabilized Contrast Agent Microbubbles

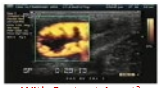
Bailey Leadford, Ajin Abraham, Bini Thankachan, Devin Whitlark

Dr. Margaret Wheatley, Brian Oeffinger, and Dr. Wan Shih

Medical Need

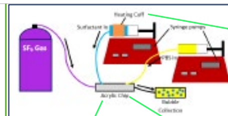
Microbubble contrast agents increase acoustic impedance boundaries between blood vessels and tissue, increasing contrast of ultrasound image.
Current methods are expensive, time-consuming, inefficient, and overall unreliable.


Without Contrast Agent[3]


With Contrast Agent[3]

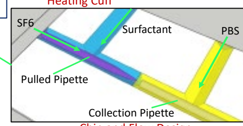
Objective: Design a device to create microbubbles of specific and consistent size and composition with minimal material waste.

Solution




Heating Cuff

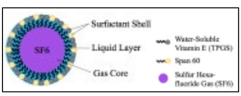

Acrylic Chip Prototype



Chip and Flow Design

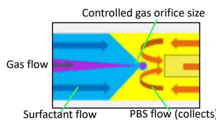
Approach

Microbubble requirements:
- Less than 6 μm diameter
- Gas core stabilized by surfactant shell
- Low polydispersity index (PDI)

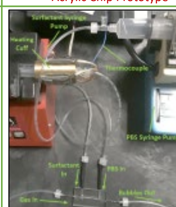


Microbubble Composition

Goals of Device:
- Create microbubbles with a PDI <0.2
- Material efficiency above 15%
- Track formation microscopically
- Heat surfactant to flow



Results


Device Test Setup

Device assembly and testing are underway:
- Heating element assembled and functional
- Multiple prototypes in assembly with good results in pipette alignment
- Tests have resulted in bubbles too large
- Flow rates of surfactant, PBS and SF6 must be fine tuned to decrease bubble size
- Chip assembly process must be perfected to reduce leakage

TEAM **2**

Mechanical Properties of a 3D Printed GelMA Scaffold

Rehani Brahmbhatt, Albina Jamekshova, Alan Liu

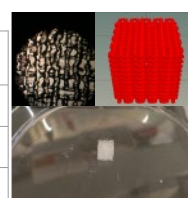
Dr. Kara Spiller

Need: 1 million distal radius fractures worldwide resulting in about $2 billion in hospital costs. Current solutions can be very costly and often require a second operation.

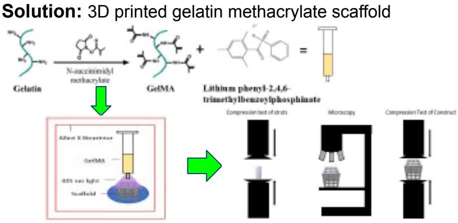
Objective: Develop a porous, low-cost, biocompatible 3D printed scaffold for rapid bone regeneration

Approach:

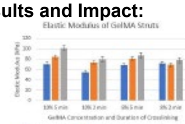
Requirement	Specification
E of Struts	60±30 kPa
Pore Size	200-500μm
E of Scaffold	Must maintain shape



Solution: 3D printed gelatin methacrylate scaffold



Results and Impact:



- Average elastic modulus of struts: **68.5±7.86 kPa**
- Average pore size: **273.161±40μm**
- Average elastic modulus of porous constructs: **0.026±0.003 Pa**

Impact: Provide a more cost effective alternative for bone tissue repair

TEAM **3**

Sensor Based Design for Monitoring of the Bone-Screw Interface

Walker Alexander, Sara Jubanyik, Spiro Kokolis, and Praneeth Meka

Dr. Joseph Sarver and Dr. Marek Swoboda

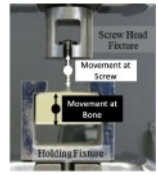
MEDICAL NEED

Deterioration at the bone-screw interface is an important mode of failure for internal fracture fixation devices, but researchers do not have the adequate tools to study this failure *ex vivo*

Current test equipment is not sufficient enough to accurately test the real life conditions of varied loading scenarios across multiple screws

SOLUTION

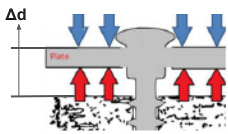
- Two accelerometers will be used to gather positional data at both the bone and screw
- By looking at "screw movement" relative to "bone movement," the quality of the interface can be determined



Accelerometers were chosen High Sensitivity (300 mV/g) and Small Operating Range (±3g)

APPROACH

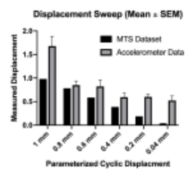
The screw will displace as the bone-screw interface has been deteriorated. Measuring the **relative displacement (Δd)** between the bone and screw can show if movement has occurred and the interface has weakened.



The solution must measure relative displacement with a **1-D spatial resolution of <0.1mm at a frequency of >10 Hz**

RESULTS & IMPACT

Initial Verification testing has shown this accelerometer-based solution will need an accelerometer that is out of the current budget, however the current design may have utility in detecting full deterioration



The impact will be an opportunity for to gather data directly from the screws allowing for a better characterization of screw failure at the bone-screw interface.

TEAM **4**

Rig for Simulating Post-surgery Assessments of Should Joint Motion

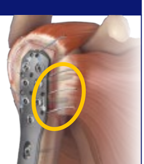
Donald Arnold, Christopher Moali, Matthias Recktenwald, and Jennifer Sanville

Dr. Joseph Sarver and Dr. Michael Hast

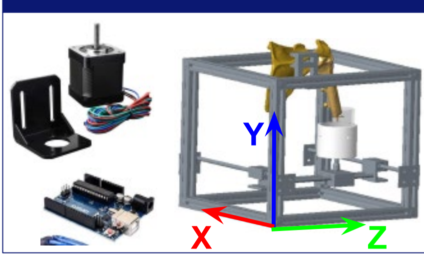
Background

-Optional sutures need testing in clinically relevant motions to evaluate failure

-Cadaveric models used, but **no current test setup creates these motions** in a lab



Solution

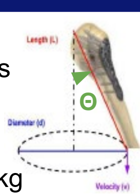


Approach

Pendulum swing:

- 0.027<*v*< 0.054 m/s
- 10°<Θ<20°
- 0.5<f<1.0 Hz

Support 2.24<W<4.54 kg



Results & Impact

-Circle fitting to collected data

-Impact: cost effective, repeatable testing method for cadaver studies

TEAM 5

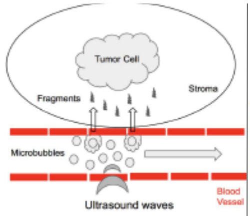
In Vitro Model of the Pancreatic Stroma for Drug Delivery Testing

Daiana Avram, Gregory Burns, Sukhdeep Gill, and Julia Innamorato

Dr. Margaret Wheatley and Dr. Adrian Shieh

Clinical Need

- Pancreatic adenocarcinoma (PDAC) is one of deadliest cancers
- Once diagnosed, 5 year survival rate of 6%
- Experimental drug delivery system (DDS) being developed at Drexel, **BUT** no realistic model to test it

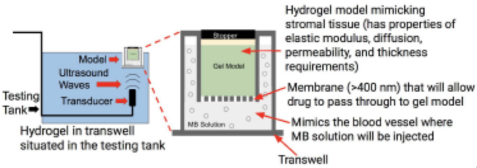


MB Drug Delivery System

Approach: To design an *in vitro* 3D **experimental model** that mimics the **mechanical and transport properties of the pancreatic tumor stroma** that can be used to test the efficacy of the MB DDS.

Solution

Gel: 0.8% Gellan Gum



Results/Impact

	Requirement	Results
Elastic modulus	5-30 kPa	26.14 ± 3.83 kPa
Diffusion Coefficient	2.44E-11 m^2/sec ±10%	7.32 E-11±1.93E-11 m^2/sec
Permeability	2.67E-15 m^2	8.79E-15 ± 4.53E-15 m^2
Thickness	5 mm	5.22 ± 0.22mm

Expected to **further drug treatment options** for PDAC, as it will provide an *in vitro* model to further **develop and improve** current methods that can go on to help the **45,000 people** affected annually.

TEAM 6

3D Printed Palatal Obturators for Pediatric Cleft Palate Patients

Amanda Barkan, Hazara Begum, Peiwen Chen,Gerard Dimen, and Jie Zhi

Dr. Adrian Shieh, Dr. Jaimie Dougherty, and Timothy Reppert

Clinical Need

- *1 in every 700* children is born with cleft palate
- Operation Smile has *limited capacity* for free reconstructive surgeries
  - ~44% of patients are turned away

Operation Smile

Unilateral Cleft Palate

Design Need

- *Alveolar Arch Collapse* occurs in 50% of unilateral cleft palate patients due to *insufficient intraoral support*

Objective

- To design a 3D printed palatal obturator that will prevent alveolar arch collapse for pediatric preoperative unilateral cleft palate patients

Solution

Obturator Material	Flexural Modulus (MPa)	Flexural Strength (MPa)
DENTCA Denture	2000	65
Rigid Polyurethane	1900	45

Design 1 - Surfacing - Uniform Thickness

Design 2 - Cleft Palate Negative - Non-Uniform Thickness

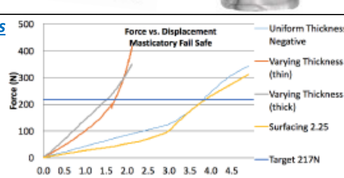
Design 3 - Cleft Palate Negative - Uniform Thickness

Approach

3D Model of Cleft Palate + ***3D Palatal Obturator Prototype*** = ***Palatal Obturator with Cleft Palate***

Requirement	Acceptance Criteria
Withstands 8.9N Alveolar Arch Collapsing Force	Medial x-displacement <0.05 mm
Withstands 217N Masticatory Fail-Safe Force	Yield point occurs before 217N

Results



- Varying thickness obturators pass masticatory fail-safe requirement

Impact

- Utilization of 3D printing and software to fabricate palatal obturators
- Operation Smile can provide untreated patients with an obturator until surgery becomes available

TEAM
7 Tissue Phantom in Speed of Sound Lab

Alec Belousov, David Corsan, David Ing, and Prashant Patel   Dr. Peter Lewin

Need

The biomedical ultrasound lab is lacking biomimetic phantoms for use in the protocol. The materials currently used, rubber and acrylic, do not have the same properties as tissue, making it difficult to convey the medical relevance.

Approach

Develop soft and hard tissue phantoms with a speed of sound of 1600 m/s and 4000 m/s respectively.

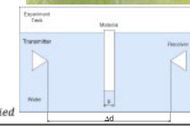
Speed of Sound key material properties defined by

$$c = \frac{1}{\sqrt{\rho_0 K}}$$

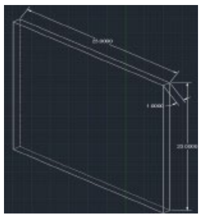
$c = speed\ of\ sound\ in\ tissue\ (m/s)$

$\rho_0 = Average\ density\ (kg/m^3)$

$K = Compressibility\ (m^2 \cdot N^{-1}) - stress\ applied$



Solution



Epoxy phantom

- 1' x 1' length and width

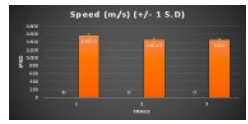
Density

1. Soft tissue: 1.06×10^6 g/m^3
2. Hard tissue: 1.9×10^6 g/m^3

Compressibility

3. Soft tissue: 3.97×10^{-13} Pa^{-1}
4. Hard tissue: 3.8×10^{-14} Pa^{-1}

Results and Impact



Verification testing and results

1. Density Measurements
2. Compressibility Testing
3. Lab Protocol Validation

The speed range from 1400-1600 (m/s) seen in the graph. The epoxy phantom is a biomimetic material that approximates the properties of skeletal muscle. This enhances the learning experience in the lab by providing a material with properties that are relevant in the context of the biomedical engineering curriculum.

TEAM
8 Mechanical Analysis of Prosthetic Suspension in Transfemoral Amputees

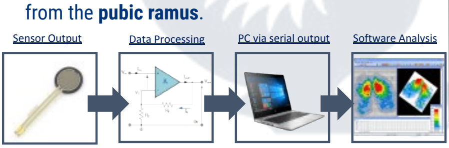
Max Bornstein, Stephanie Gebbia, Jon El-Khoury, and Christian Hamm   Dr. Ken Barbee and Dr. Meg Lockard

Clinical Need: The residual limb of a lower limb amputee is subjected to significant forces. These forces can affect prosthesis **function** and **comfort**.

Current Solutions: Existing evaluatory systems focus on the **distal** limb-prosthesis interface.

Validation: To validate the sensor suite, a **test limb** is being developed. This test limb is comprised of *Synbone* ® bone simulate and *Humimic*™ ballistics gelatin. The test limb will be loaded with a biological schema to mimic **gait**.

Solution: A sensor suite will gather data in the **region of interest** - the **proximal** limb-prosthesis interface - assessing forces due to interactions from the **pubic ramus**.



Results and Impact: This system is being developed as a **diagnostic aid** to facilitate prosthetists during fittings and office visits.

Conversations with external stakeholders have indicated that **data-driven** solutions may prove favorable when liaising with insurance companies.

TEAM

9

EyeLab: An Assistive Laboratory Application for Students Who Are Blind or Visually Impaired

Haoyang Chen, Aida Kupa, Junyu Lu, and Pushpita Rahman

Dr. Catherine von Reyn

Problem and Need : Legally blind persons are highly underrepresented in STEM (especially chemistry). K-12 participation in laboratories increases STEM interest. For blind students interacting with chemicals is unsafe and identifying physical attributes, specifically color, is difficult.

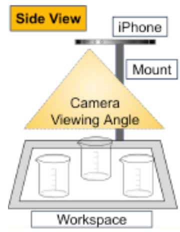
Objective : Develop a visual-substitution application to identify chemistry equipment and track color in real-time.

Solution :

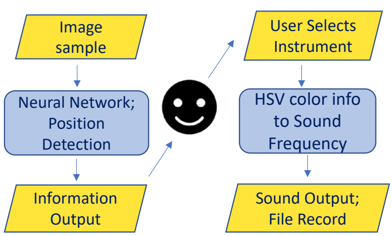
Object identification, position detection, and color tracking.

Consists of

- iPhone App
- Phone Mount
- Chemical Tray



Approach : Application Schematic



Results :

Verification Test	Result	Req.
Neural N. Accuracy	94.8%	>90% ✓
Latency	32.9 ± 16.9ms	<90ms ✓
Sampling Rate	11.11Hz	>10Hz ✓

Impact : Increased independence and participation of blind students in Chemistry laboratories. Allowing STEM fields to potentially gain access to 54 million legally blind individuals worldwide.

TEAM

10

Laryngoscope Cover for Pediatric Intubations

Kenny Chen, Irelyn McIver, Anley Samuel, and Amber Saraceni

Dr. Lin Han and Dr. Ian Yuan

Medical Need

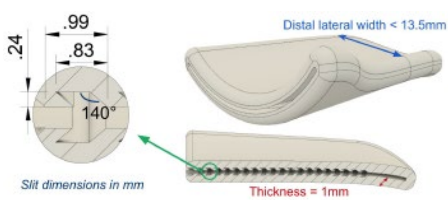
A stainless-steel laryngoscope causes trauma in small and fragile pediatric airways, leading to a higher risk of complications in clinical settings.

Existing solutions apply too much pressure onto the tissues and/or are not fit for cost-efficiency and effectiveness.

Objective: To design a device that prevents larynx injuries occurring from current pediatric intubations.

Solution

Implement a silicone cover for the distal end of a Miller 1 laryngoscope. **Intended Material: PDMS**

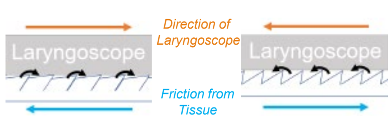


Approach

Design a **force absorbing silicone cover** that is **custom fit** to the Miller 1 laryngoscope.

Angled cuts along the cover's interior surface will use **anisotropic friction** to ensure the cover remains on the blade. Resistance depends on pull direction.

Key Requirements
Distal lateral width ≤ 13.5 mm
Convex surface thickness ≤ 2 mm
Tensile strength ≥ 1.51 MPa
Withstand ≥ 20 N before slippage
Fracture point under uniaxial loading with cover ≥ without



Results

Requirement	Test	Results	Pass / Fail
Tensile Strength	ASTM D412-16	1.80 MPa (PDMS 48A)	Pass
Fracture Point	3-Point Bend	4.83 N without cover	TBD
Applied Forces	Apply uniaxial shear force from blade with cover onto tissues	TBD	TBD

Impact: The final product will decrease the number of intraoperative complications from current pediatric intubation procedures and increase patient comfort.

TEAM
11 Patient-Specific Alignment Device for Total Ankle Replacement

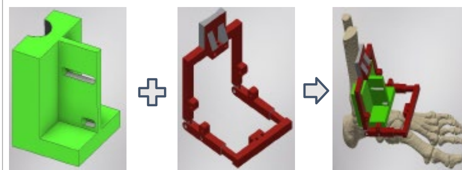
Shawn Cherian, Jacqueline Gorberg, and William McLaughlin

Dr. Sorin Siegler and Dr. Fred Allen

Clinical Need:
TAR surgery often results in malpositioning complications
- ~ 44% revision rate after 10 years

Objective:
Design improved alignment device that can be used with all anterior TAR implants

Solution:

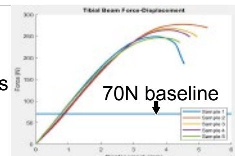


Patient-Specific Component + Adjustable Alignment Frame → Total Alignment Construct

Approach:
Scan ankle joint → Make 3D printed component → Align joint with 3D component during surgery

Requirements:
- Joint alignment to ±5° of CT scan position
- Joint articulation of 15°-25°
- Minimally obstructed surgical window
- Withstands max force of 70N

Results:
✓ Alignment Frame withstood > 70N
✓ Anterior TAR implant fits within surgical window



Impact:
Decreased malpositioning → Revision surgery need ↓ → $16,000 savings

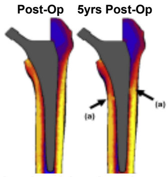
TEAM
12 Design of Porous PEEK Topologies Using Fused Filament Fabrication

Colin Burlingham, Kenny Cho, William Hartley, Anthony Law, and Wing Ni Lee

Dr. Steven Kurtz and Dr. Michael Frohberg

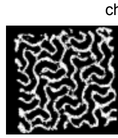
Need:
Metallic orthopedic implants → rectify bone pathologies or injuries

Difference in Young's modulus at implant/bone interface causes stress shielding - **(a)** reduction in bone density

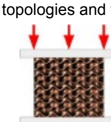


Select a topology design for fabricating biomimetic bone structures via Fused Filament Fabrication

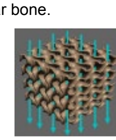
Approach:
Perform series of tests to compare material properties between chosen topologies and trabecular bone.



μCT Imaging



Compression Testing



Permeability Testing

Solution:

Printing Parameters -

A) *Gyroid V2*
- Strut Width – 0.30 mm
- Pore Size – 450 μm
- Porosity – 72%

B) *Rectilinear*
- Strut Width – 0.25 mm
- Pore Size – 600 μm
- Porosity – 70%

Results:

Topology	Pore Size (μm)	Porosity (%)	Permeability (μm²)	Young's Modulus (MPa)	Compressive Yield Stress (MPa)
Gyroid V2	706.0 ✗	65.82 ✓	557 ± 24.7 ✓	347.4 ± 9.53 ✓	18.68 ± 0.60 ✓
Rectilinear	588.6 ✓	73.20 ✓	1500 ± 10.7 ✗	217.0 ± 17.09 ✓	7.36 ± 1.16 ✓

Gyroid failed the pore size requirement and passed all other requirements. Rectilinear failed permeability requirement and passed all other tests.

Impact:
Minimize stress shielding of implant bone interface, which will reduce the need for revision surgery

TEAM **13**

Electro-acoustic Optimization of Ultrasonically Assisted Chronic Wound Healing Applicator

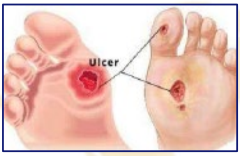
Abby Kaplan, Austin Devinney, Davin Ross, Josh Propper, and Sunyi Kim

Dr. Peter A. Lewin and Olivia Ngo

Background and Medical Need

What are Chronic Wounds?

- Wounds that do not improve after 4 weeks or heal in 8 weeks
- Last on average **12 to 13 months**
- Impacts **6.5 million** people annually



Objective:

Our goal is to improve the current electro-acoustic wound healing applicator to maximize acoustic output by identifying the most effective piezoceramic materials.

Our Solution

Increase Acoustic Output → Minimize Excitation Voltage → Decrease Applicator Size

Hypothesis:

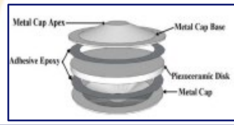
- A higher d_{33} will lead to larger acoustic output.

New Material Specifications:

- PZT-52 d_{33}: 420 (10^{-12}C/N)
- PZT-54 d_{33}: 500 (10^{-12}C/N)

Current Material Specifications:

- PZT-26 d_{33}: 290 (10^{-12}C/N)

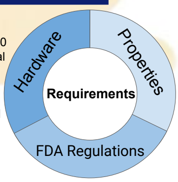


Approach

Properties
- d_{33} > 400 pC/N

FDA Regulations
- Ultrasound intensity of 100 mW/cm^2 to prevent inertial cavitation

Hardware
- Acoustic output more than 19.5 kPa generated
- Maintain frequency of 20 to 100 kHz
- Excitation of less than 11 V



Approach:

Research New PZT Ceramics → Construct Current Applicators → Construct New Generation Applicators → Review and Reject

Results and Impact

	d_{33} Values (pCN)	Frequency (Hz)	Acoustic Output (kPa)
PZT-26	401.22 +/- 3.48	25.45 +/- 2.17	19.57 +/- 7.04
PZT-52	601.5 +/- 12.1	24.59 +/- 1.09	29.70 +/- 4.87
PZT-54	589.9 +/- 13.0	24.61 +/ 0.78	39.64 +/- 9.84

Impact: Utilizing the new PZT materials will allow us to minimize excitation voltage, which allows the applicator size and weight to be decreased. The lighter, smaller applicator increases portability and therefore quality of life for patients.

TEAM **14**

MXene Filter for Hemodialysate Regeneration

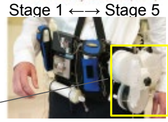
Jonathan Fabian, Eliot Precetti, and David Yasgur

Dr. Yuri Gogotsi and Dr. Mykola Seredych

Need:

- 13.6% of the global population have Chronic Kidney Disease (CKD)
- Stage 4 & 5 are fatal if untreated
- A portable hemodialysator would be healthier for patients but is currently *too bulky*

Chronic Kidney Disease (CKD)
Stage 1 ⟵⟶ Stage 5

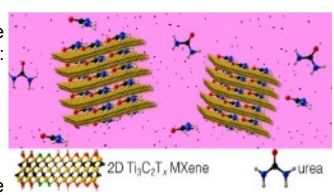


Wearable artificial kidney with dialysate regeneration system highlighted

Solution:

Titanium Carbide MXene ($Ti_3C_2T_x$):

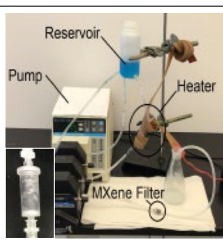
- High Surface Area
- Surface Functional Groups
- Biocompatible



Approach:

Find a sorbent that:

- does not chemically react to dialysate
- Has a high affinity for urea
- Nontoxic

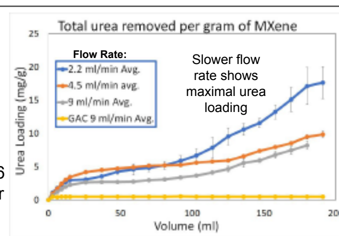


Main Requirement:

- Sorbent must be able to load at least 3.31 mg of urea per gram of sorbent

Results:

- MXene out-performs activated carbon (GAC) solutions
- Maximum loading of 17.6 mg of urea per g of MXene



TEAM

15

Design of Optimized Detection Method of Breast Cancer Specific Molecule

Priya Gupta, Raadiya Qadeer, Hayley Roth, and Virginia Tanner

Dr. Wan Shih and Dr. Wei-Heng Shih

Medical Need:

1 in 8 women develop breast cancer

25 % need re-excision surgery = $4700+/procedure

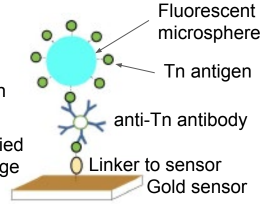
Objective:

Develop a **specific, molecular-based intraoperative margin assessment** that limits the removal of healthy breast tissue

Solution:

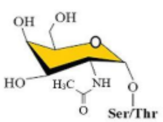
Fluorescent microsphere used to **detect Tn antigen** on surface

Microspheres quantified using **automatic** image analysis



Target:

Rapidly identify **Tn antigen**, a surface molecule expressed in **90%** of breast cancer cells



Tn antigen

Approach:

Reduce time of current protocols by:

(1) studying effect of temperature on antibody and Tn antigen interaction to **reduce incubation time**

(2) automating image analysis **(< 1 min)**

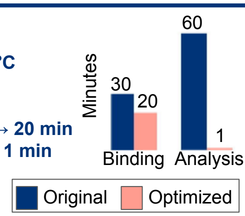
Results:

Optimal Temperature: **37 °C**

Time Reduction:

Binding Protocol **30 min → 20 min**

Image Analysis **60 min → 1 min**



Impact:

Further development of this approach could improve surgical outcomes and reduce the need for re-excision surgery

TEAM

16

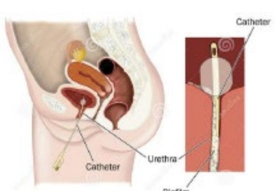
Non-antibiotic Antimicrobial Coating for Urethral Catheter Application

Alyson Hurlock, Sona Mathew, and Jamie Trinh

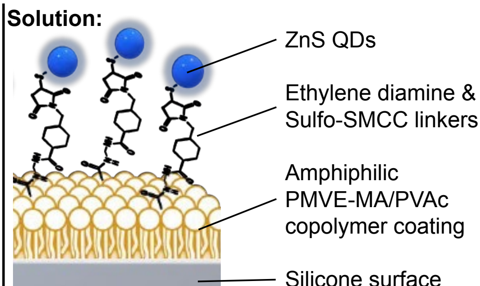
Dr. Wan Shih and Dr. Wei-Heng Shih

Need: 75% of patients that receive catheters obtain UTIs, which are often antibiotic resistant. Current solutions are antibiotic based and ineffective.

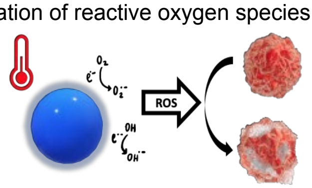
Objective: Create a non-antibiotic, antimicrobial coating to reduce UTI occurrence



Solution:



Approach: Incorporating quantum dot (QD) technology to induce bacterial apoptosis via generation of reactive oxygen species (ROS).

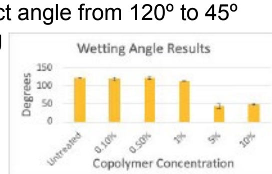


Requirements: (1) Coating angle <60°
(2) Reduce bacterial growth by at least 50%

Results:

(1) Reduced contact angle from 120° to 45°

(2) Bacterial testing shows copolymer coated silicone reduced bacterial growth by ~30%



Impact: Reduce UTI occurrence, its $350 million healthcare burden, and the 2 million antibiotic resistant infections each year

TEAM

17

Deep Tissue Injury (DTI) Detection Using Piezoelectric Finger (PEF) Technology

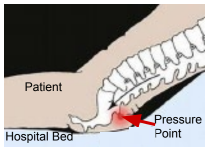
Eric John, Amanda Joyce, and Meenakshi Patel

Dr. Wan Shih, Dr. Wei-Heng Shih, Dr. Michael Neidrauer, Dr. Michael Weingarten, and Dr. Richard Huneke

Need

Deep tissue injury (DTI) are pressure injuries developed near bony prominences by sustained loading and shear forces

Hospitals need to **detect DTI** on admission and start early treatment **to prevent complications**



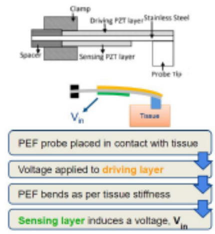
<u>No Current Solutions</u> can accurately detect length, width, and depth of DTI

Solution

Use **Piezoelectric Finger (PEF)** device to measure **Elastic Modulus(E)** by measuring changes in *induced voltage*

$$E = \frac{1}{2}\left(\frac{\pi}{A}\right)^{1/2}(1-\nu^2)\frac{K(V_{in,0}-V_{in})}{V_{in}}$$

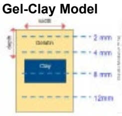
E = elastic modulus of tissue*; A = surface area of probe tip; ν = Poisson's ratio of tissue; K = spring constant of PEF; $V_{in,0}$ = voltage induced without tissue; V_{in} = voltage induced with tissue*[8]



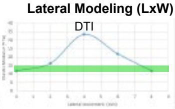
Approach

A set of **4 PEF probes** with increasing depth sensitivity to detect width, length and depth of DTI. Clay embedded in gel to represent DTI under skin. **Elastic modulus** recorded for a given probe **increases** if clay (DTI) was present

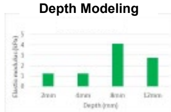
Gel-Clay Model



Lateral Modeling (LxW)

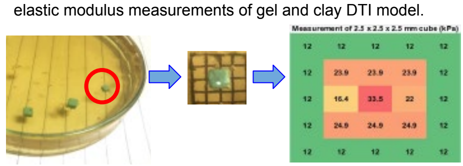


Depth Modeling



Results

Successfully measured **changes in elastic modulus** of using PEF Sensor. A 2D heat map at depth of 2 mm displays the elastic modulus measurements of gel and clay DTI model.



TEAM

18

Astronaut Hibernation Monitor

Davina Lee, Chloe Jonas, Parmpuneet Kaur, Sean Verillo, and Roxanna Tehrani

Dr. Kambiz Pourrezaei

Need

Hibernation for a manned Mars mission can reduce:

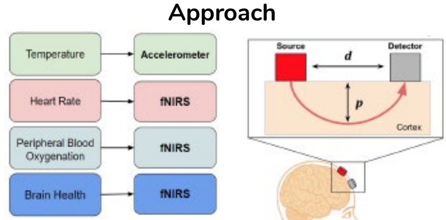
- Costs/Resources
- Physiological/Psychological stress

A device is needed for:

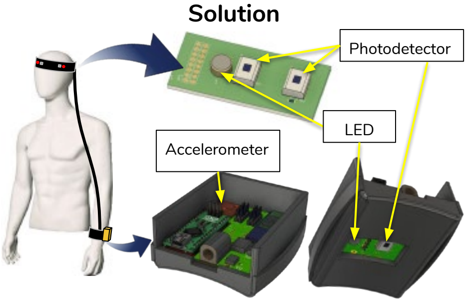
Health Monitoring

Metabolic State Determination (MSD)

Approach



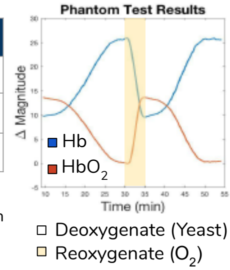
Solution



Conclusion

Test Case	Result
Cerebral Probes (Phantom Test)	PASS
Wrist Device (HR, SpO_2, Shivering)	PASS
Software (MSD, Alerts)	PASS

Impact: Potential for platform technology for applications such as patient stabilization and therapeutic hypothermia



TEAM

19 Electromyogram Based Interface for Real-Time Tracking of Natural Limb Activity for Avatar Control in Virtual Environments

Henry Tse, Khang Vu, Cory Zheng

Dr. Hasan Ayaz

Need:

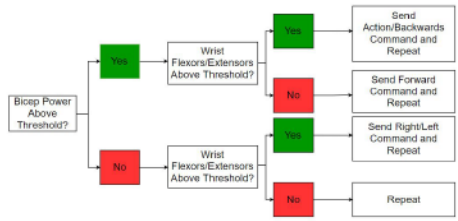
Virtual Environments are widely utilized and have diverse application domains

Human-computer interaction with Virtual Environments still relies on outdated input mechanisms designed for first-generation computational devices

There is an unmet need for low-cost, reliable, durable, and safe technologies that enable user to interact with Virtual Environments

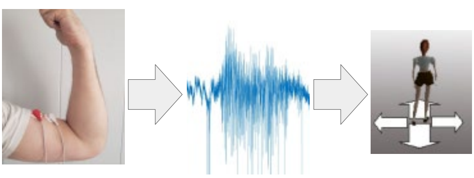
Solution:

Muscle activity monitored, processed, and classified in real time with output in Mazesuite



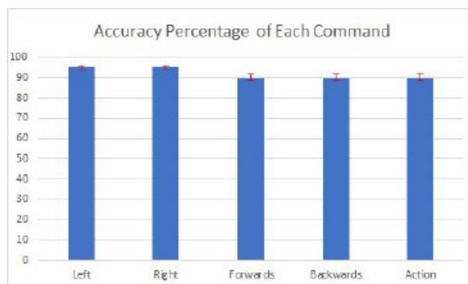
Approach:

Utilize electrical activity generated in muscles during contraction as an input to a virtual environment



Classify muscle activity patterns into distinct commands for use in controlling a virtual avatar

Results:



TEAM

20 Mid-Fidelity Simulator Model for Training Cesarean Section in Kampala, Uganda

Rachel Junod, Michelle Krach, Lyndsey Sbarro, and Victoria Utria

Dr. Michele Marcolongo and Dr. Owen Montgomery

Need: Uganda has a shortage of physicians **trained** in cesarean section (CS) leading to high maternal mortality

Objective: Create an accurate CS **training model** to improve accessibility and quality of training

Design Needs:

- Anatomically Accurate
- Mechanically Accurate
- Low Cost ($1/use)

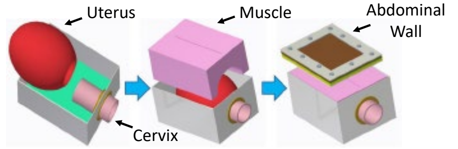
Doctor: Patient Ratio

1:24,725

Maternal Mortality

343 in 100,000

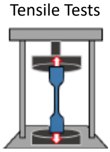
Solution: Silicone model with removable, interlocking components for part task training and multiple uses



Approach:

Material Selection

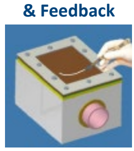
Tensile Tests



Model Design

Prototypes

Physician Testing & Feedback



Results: Although some mechanical requirements were not met, physician stakeholders approved the model

Component	Mechanically Accurate	Physician Approved
Skin	✗	✓
Fat	✓	✓
Muscle	✓	✓
Uterus	✗	✓

Impact: Access to affordable, accurate training worldwide

TEAM

21 Rhythmic Auditory Stimulation for the Enhancement of Declarative Memory

Blake Kazaoka, Charles Preletz, Kaitlyn Reid, and Sean Van Duser

Dr. Donald McEachron

Medical Need/Demographic

Elderly

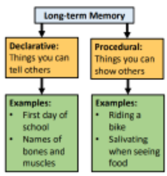
- Declarative memory increases as we age
- Increased life expectancy leads to more individuals suffering from the effects of aging.

College Students

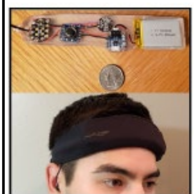
- Constantly changing schedule
- Late-night studying and early morning classes

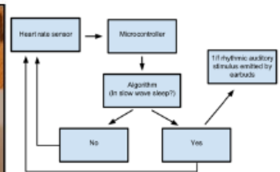
Objective

Improve a user's declarative memory by applying rhythmic auditory stimulation while they sleep, using a device that is affordable and comfortable to users without increasing total time slept.

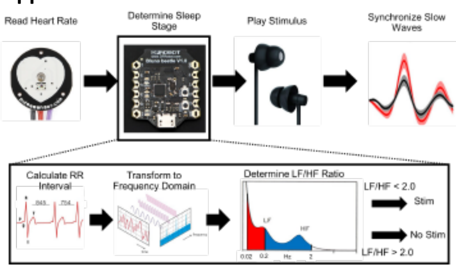


Solution





Approach

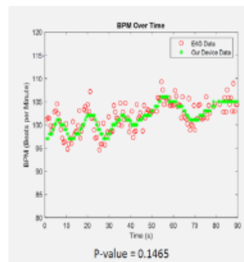


Results/Impact

Results:

- The design was able to accurately record heart rate while worn
- The design is able to dispense the auditory stimulus properly

Impact: With the design ready for function, the validation of increasing declarative memory can occur



TEAM

22 A Novel Micro-Fabricated Device for Non-Viral Transfection for Adoptive Cell Therapy Manufacturing

Michael Dasilva, Johnathan Lawless, and Pavan Patel

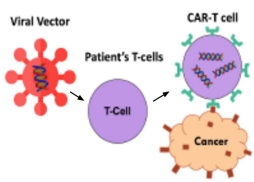
Noah Clay, Meredith Metzler, Dr. Joseph Fraietta, Dr. Michael Bouchard

Need

CAR-T Therapy is a novel treatment option for cancer.

CAR-T Manufacturing requires sterile suites for viral engineering methods.

Non-viral approaches for gene delivery can reduce cycle times in clean rooms



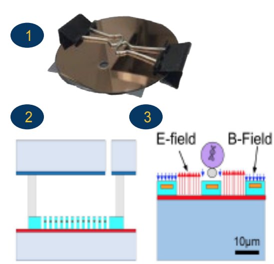
Goal: Create an electroporation chamber for automation of magnetic cell isolation and non-viral gene delivery for CAR-T Therapy

Solution

Requirements:

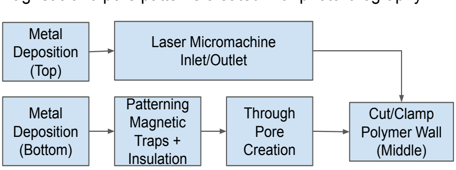
- Inlet hole for pipetting
- 300µm electrode spacing
- $1x10^6$ cell throughput
- Insulated magnetic traps

(1) Early prototype design
(2) Cross section
(3) Schematic

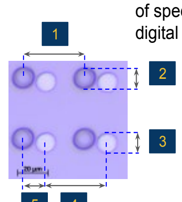


Approach

- Microfabrication of the chamber with glass wafer substrates
- Magnetic and pore patterns created with photolithography



Results



Conclusion: Successful fabrication of the top and bottom wafers - dimensions 2, 3, and 5 out of spec but viable. Verification performed with digital microscopy and 2D profilometry.

Specifications Verified:

✓ 1. Pore Center-to-Center
~ 2. Through Pore Diameter
~ 3. Magnetic Disk Diameter
✓ 4. Magnet Center-to-Center
~ 5. Magnet-Pore Spacing
✓ 6. Wall Height
✓ 7. Inlet Diameter

TEAM

23

Polarized Light Apparatus for Analyzing Collagen Structure Within Ligaments Under Load

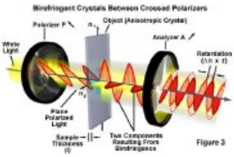
Tran Ly, Alan Nguyen, Renoj Roy, and Malik Tlili

Dr. Joseph Sarver

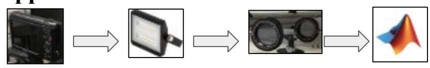
Need

Medical Need: Implement polarized light imaging to study collagen fiber orientation under tensile load

Design Need: Develop a device to facilitate students' learning of mechanical properties of ligaments and tendons



Approach



Determine Camera Resolution → Determine Uniform Light Intensity → Precisely Rotate Polarizers → Analyze Data in MATLAB

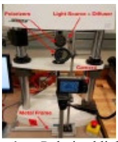
Requirements:

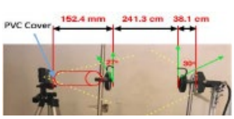
Light Source Intensity	Rotating Polarizers	Camera Resolution	PVC Cover
> 2 watts	θ ± 0.5 deg	101 x 101 Pixels	0 deg Non-Polarized Light

Constraints:

Budget	Time	Camera Resolution	Space
$500	1 hr 50 min Lab Period	101 x 101 Pixels	460 mm X 152 mm X 254 mm

Solution

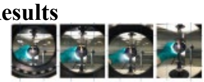




Modified Solution: Polarized light apparatus tailored to the dimensions of the Bose Testing Machine

Function: Uniform diffused light passes through rotating polarized sheets while images are captured by the camera for MatLab Analysis

Results



Color Map Intensity By Region:

Each image represents a different angle and is subdivided into portions. Light intensity value of each region for each image is found by calculating the average intensity of all pixels in region. A heatmap for the difference in light intensity at the angle with the max brightness and the angle for the lowest brightness is found for each region

TEAM

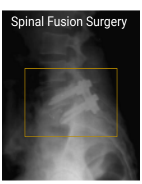
24

3D Printed Bioresorbable Antibiotic Clip for Prevention of Spinal Surgical Site Infection

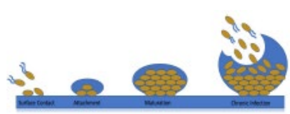
Rochitha Nathan, Manisha Rajaghatta, Brinda Shah, and Alyssa Suarez

Dr. Steven Kurtz

Medical Need

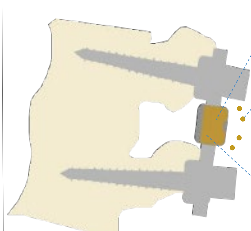


Surgical site infection is especially hard to eradicate due to biofilm formation which affects 8.5% of patients after spinal fusion surgery is performed



Design Need: Combine instantaneous and bolus release of antibiotics to treat SSI and reduce rehabilitation time, cost, pain for patients

Approach

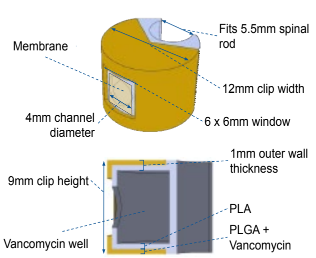


Bolus release of vancomycin is delivere ultrasound within 7 days of implantat

Vancomycin in the material of the dev releases as the clip degrades in the b

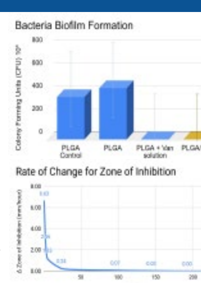
The clip incorporates a dual wall desi where the inner layer of polylactic ac (PLA) provides structural support for bolus release and the outer layer is composite poly-lactic-co-glycolic ac (PLGA 85:15) and vancomycin mater

Solution



Results

- PLGA/vancomycin composite material proved to be biofilm resistant and chemically stable after thermal-processing.
- Device was able to fit and stay onto a spinal fusion rod that endured physical force.
- Device was able to hold a capacity for the bolus release dosage.
- Mass loss was achieved in the degradation test, however the required mass loss percentage was not achieved.
- Outer layer of the device was able to release antibiotic, however the goal of beyond 7 days was not met.



TEAM

25

Assistance Call Device for Advanced ALS Patients

Chadwich Dotson-Jones, John Furey, and Andres Gutierrez

Dr. Joseph Sarver

Medical Need:

ALS is a progressive neurodegenerative disease resulting in loss of functional movement and/or speech requiring constant caregiver supervision

Hand contractures seen in ALS patients

Design Need:

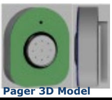
Adaptable device which will allow patients with advanced stage ALS to call a caregiver, with minimal force and movement

Solution:

- Repositionable
- Adjustable force threshold
- Rechargeable
- Wireless signal transmission
- Auditory, visual, and haptic feedback

FSR trigger modeled on hand

3D Model View of FSR Trigger



Pager 3D Model

Approach:

Existing Solutions Limitations
- Movement of limb
- Minimal Adjustability
- Not fixed on rigid surface

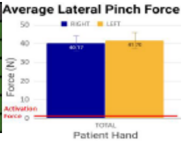
Device Objective
- Lateral pinch activation
- Adjustable to disease progression
- Fixed on *rigid* surface

Preserved Movement in ALS
- Lateral pinch

Solution

Results:

Requirement	Verification Test	Pass/Fail
Adjustable Sensor Placement	Finger Morphology	
0.2 N Activation Force	Activation Force	
20 Meter Alarm Range	Transceiver Alarm Range	
Rechargeable Battery/Alarm	Low Battery Alarm	
Feedback Call Indicator	LED Feedback Indicator	
Internal Device Supervision	Internal Supervision Alarm	



Impact:

- Quality of life and safety of patient
- Ease caregiver burden

NOTES

NOTES

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