

Biggest problem in regenerative medicine

- Despite claims otherwise: **Stem cells don't do anything *in vivo*** (they die!)
- They lack survival signals and have nothing to hold on to...
- 3D Scaffolds were invented for this purpose: tissues can organize *in vivo*
 - They provide an extracellular matrix and structure
 - They can be incorporated with growth factors, anti-microbials, directional cues, adhesion molecules, immune suppressive factors
 - They need to be biocompatible, biodegradable, appropriate mechanical properties, pore size and surface topography

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Regenerative Medicine Program at UNMC

Focus on engineering

Versatile expertise: Many projects can be approached simultaneously

Electrical engineering:

Drug delivery
Cell signaling

Bioprinting:

Cell matrices
Growth factors
Stem cells

Nanomaterials

Electrospray
Nanoparticles
Antimicrobials
Growth factors



Areas of
interest



Wound
healing



Biofilm
resolution



Peripheral
nerve repair



Rotator cuff
engineering

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Dr. Siwei Zhao

Expertise:

- Biomedical device development
- Electrical stimulation
- Drug delivery
- Wound healing
- Biofilm treatment

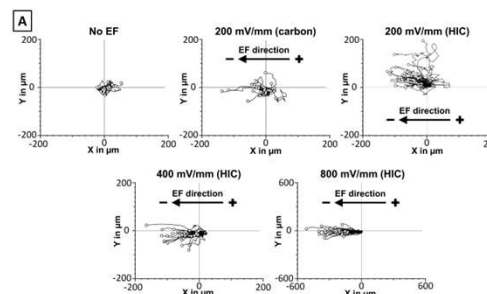
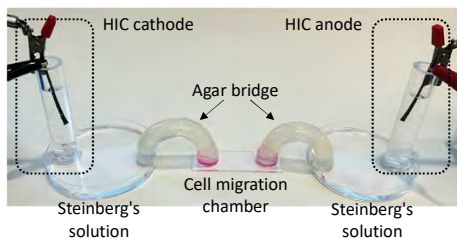
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Project 1: A novel and efficacious electrotaxis system for enhancing chronic wound healing

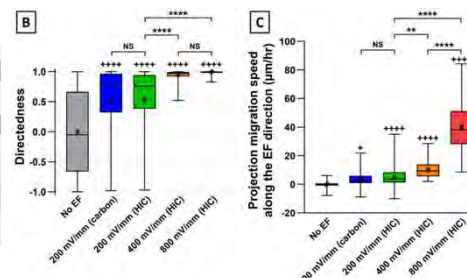
Objectives

Our *main objective* of this project is to develop a novel hydrogel ionic circuit (HIC)-based electrotaxis system that can safely apply high-intensity direct current electric field to *in vivo* skin wound tissues to guide directional migration and increase the migration speed of skin cells into the wound to significantly accelerate the healing of chronic wounds.

In vitro electrotaxis cell migration setup



Panel A shows the hairline plots representing the movement of individual human keratinocytes for unstimulated and electrotaxis-stimulated cells. All cell migration tracks start at the origin (0,0) and end at the open circles. Compared to the random migration of unstimulated cells, stimulated cells exhibited directional migration toward the cathode at 200 (for both carbon and HIC electrodes), 400, and 800 mV/mm.



Panel B and C show the directedness (B) and projection migration speed (C) of human keratinocytes. Increasing electric field strength led to significantly higher directedness meaning more directional cell migration toward the cathode. Increasing electric field strength also significantly accelerated projection cell migration speed along the electric field direction.

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Dr. Jingwei Xie

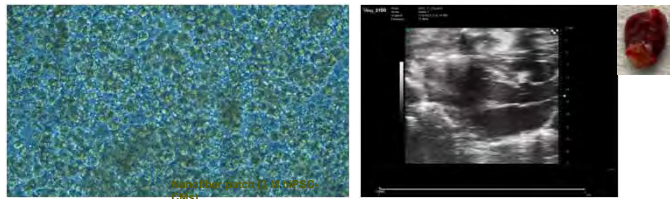
Expertise:

- Biomaterials
- Nano/micro-fabrication
- Drug Delivery
- Tissue Engineering
- Regenerative Medicine

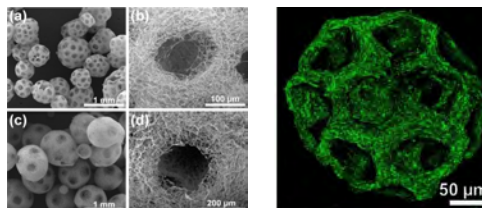
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New Forms of Electrospun Nanofiber Materials for Cell Transplantation

Minimally invasive delivery
of 3D tissue constructs



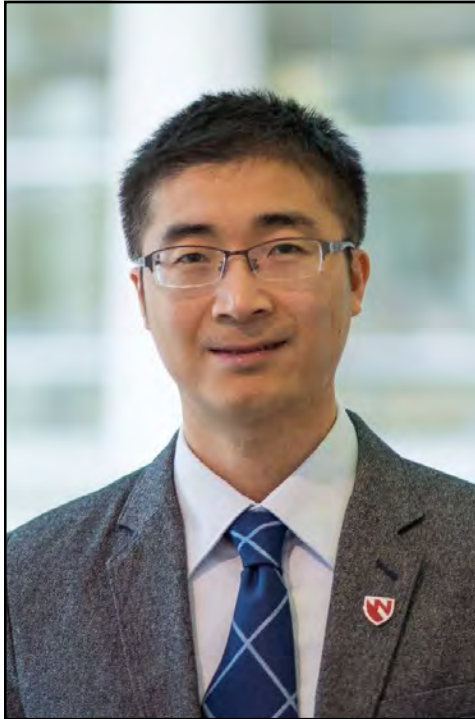
Injectable nanofiber
microspheres



Unpublished data

Xie et al. *ACS Biomater. Sci. Eng.* 2021, 7, 2204-2211
Xie et al. *Small* 2020, 16, 1907393

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Dr. Bin Duan

Expertise:

- Biomaterial design a synthesis
- 3D bioprinting
- Drug delivery
- In vitro model and cell-matrix interaction
- Tissue repair and regeneration

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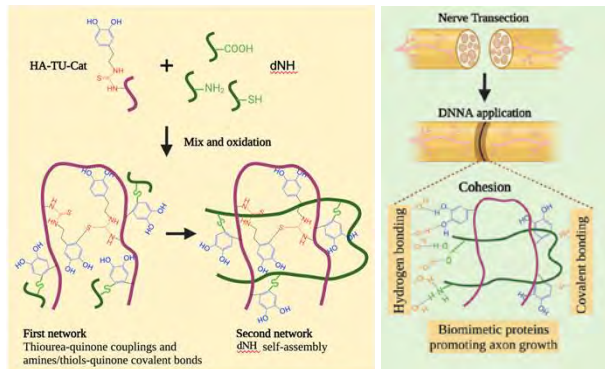
A Dual-Network Nerve Adhesive with
Enhanced Adhesion Strength Promotes
Transected Peripheral Nerve Repair

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Dual-network nerve adhesives (DNNA)

Design principles

1. Strong adhesion strength
2. Support nerve regeneration



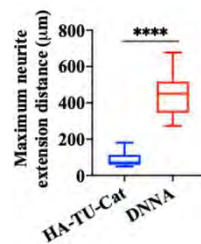
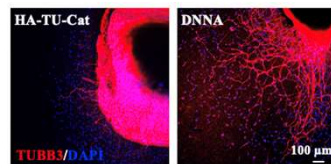
DNNA consists of modified hyaluronic acid (HA-TU-Cat), decellularized nerve hydrogel (dNH)

Wen Xue, et al. *Advanced Functional Materials*, 2023

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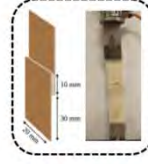
Biocompatibility and robust adhesion of DNNA

DNH addition promotes neurite outgrowth

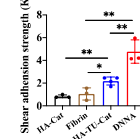
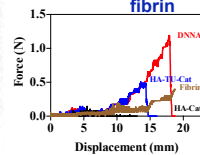


Strong shear adhesion strength

5 times higher than fibrin

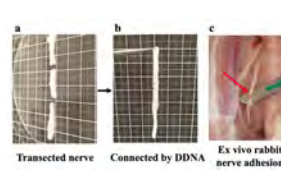


Lap shear test

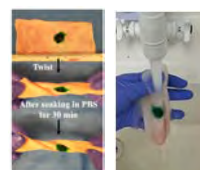


Successful ex vivo and wet adhesion

Rabbit sciatic nerve



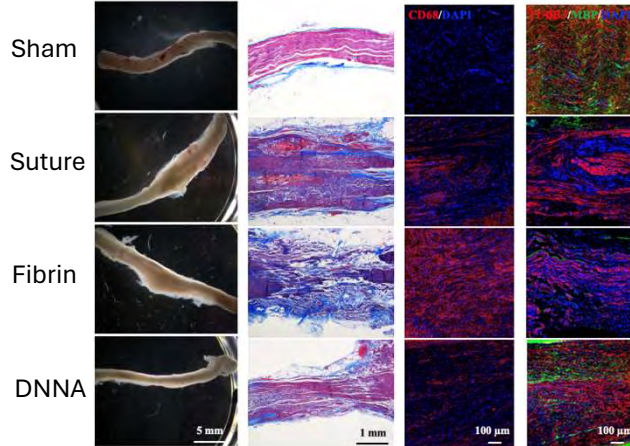
Wet environment



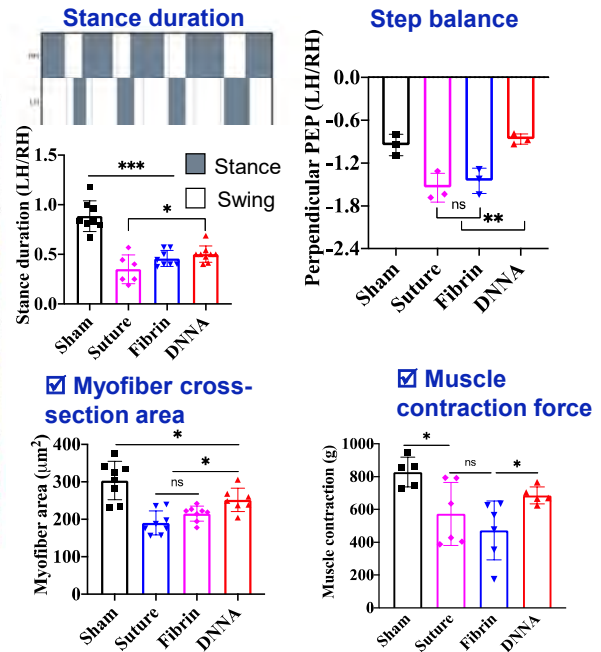
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DNNA promotes nerve reconnection and improves sensory and motor function recovery

10 weeks after surgery



- Less fibrosis
- Less macrophage infiltration
- Directed nerve reconnection



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