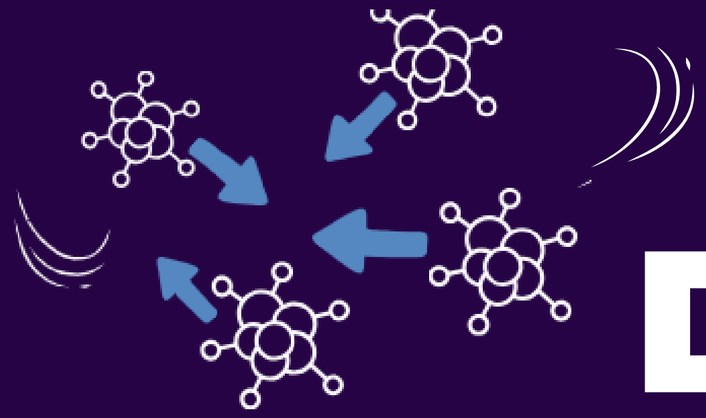
“Dancing Molecules: Adaptive Scaffolds for Tissue Regeneration”

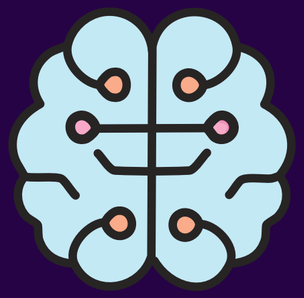
Bhagat H. & Sarbajit S. (CYSF 2026)

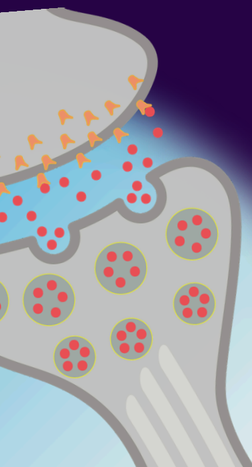


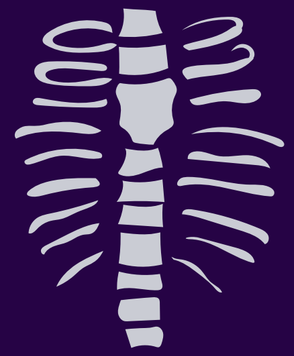
Grade 8: Tom Baines School

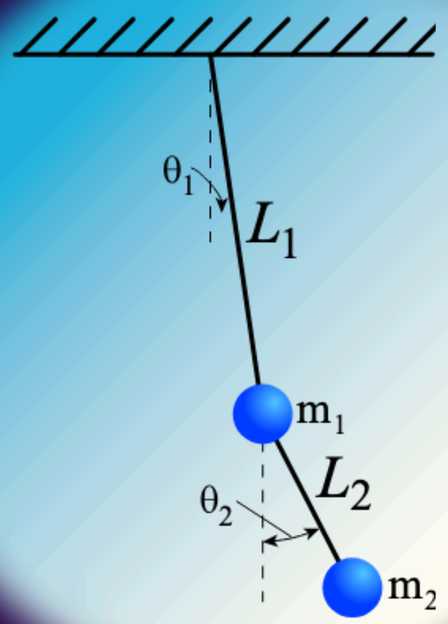
DANCING MOLECULES

Bhagat H. & Sarbajit S. (CYSF 2026)



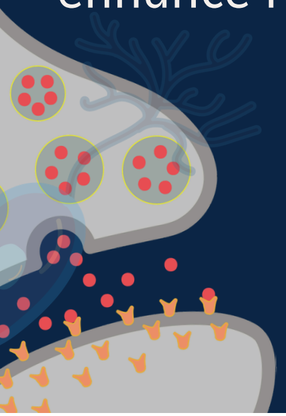


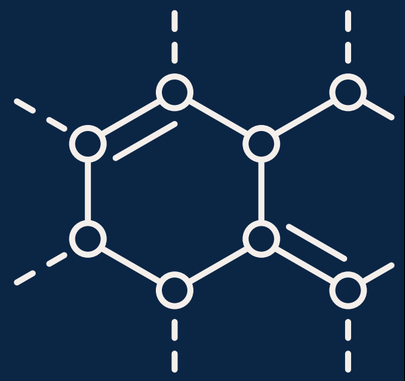


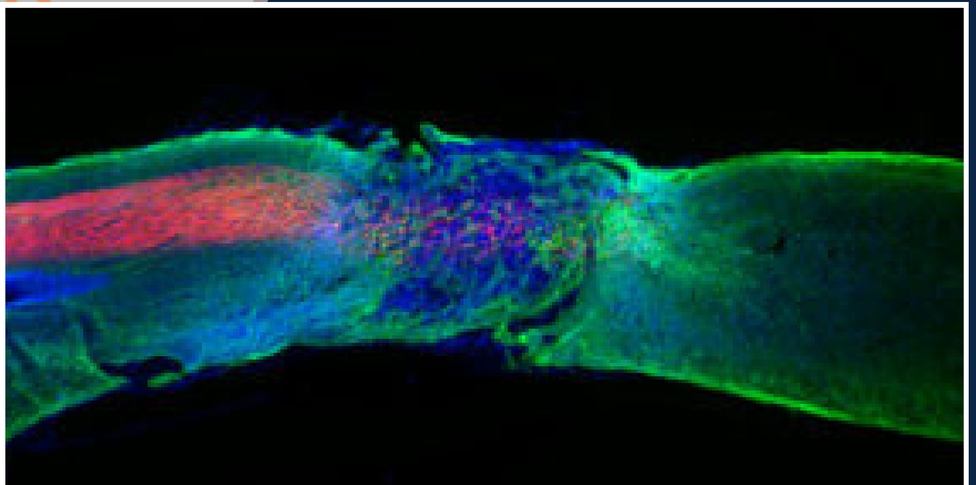


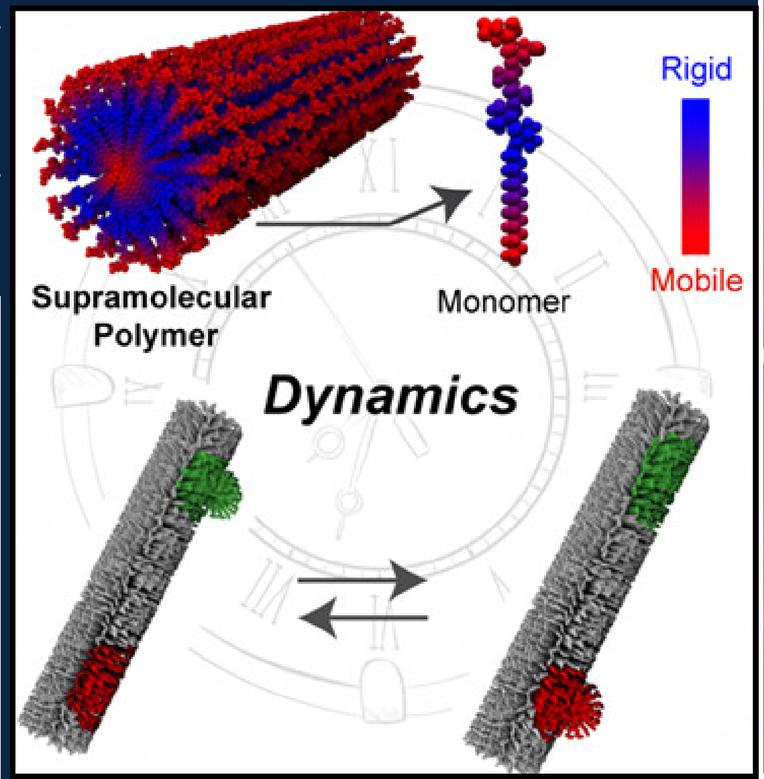
Motivation

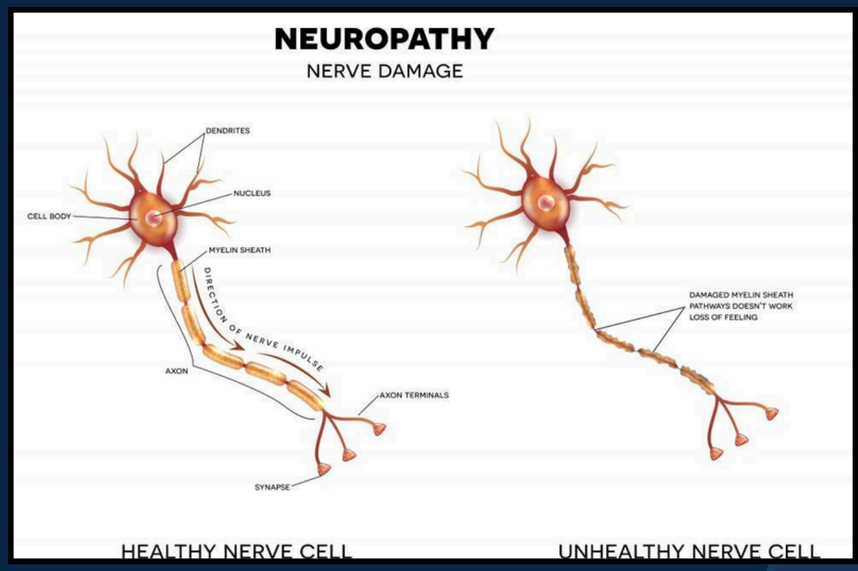
Spinal cord injuries disrupt neural communication, and while current scaffolds provide structural support, incorporating motion may enhance regenerative interaction and alignment.

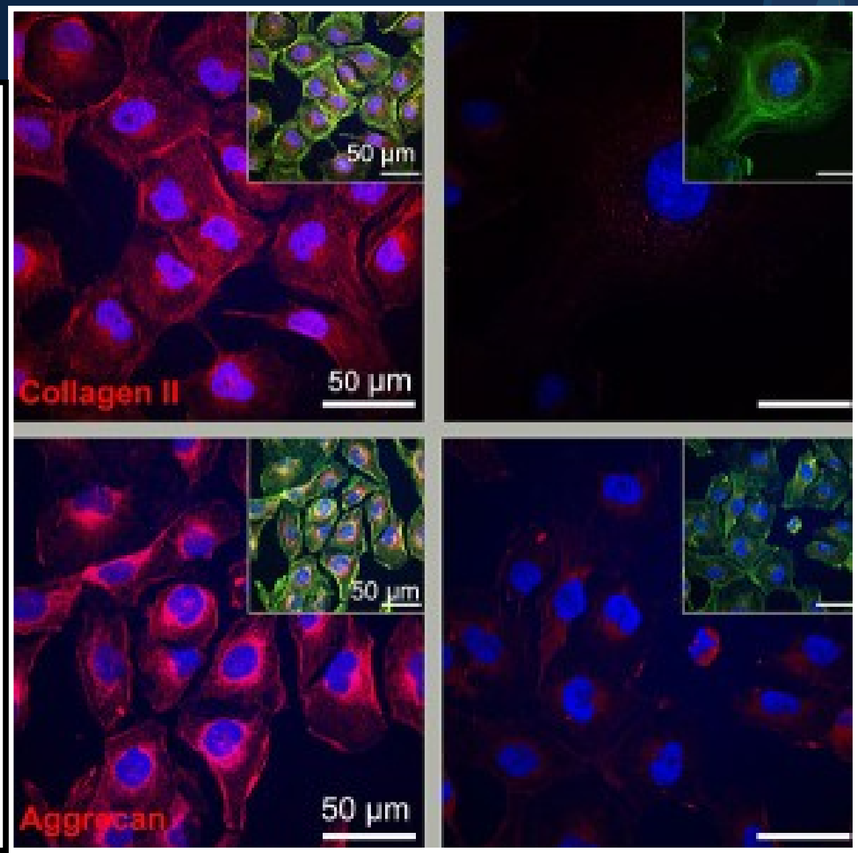






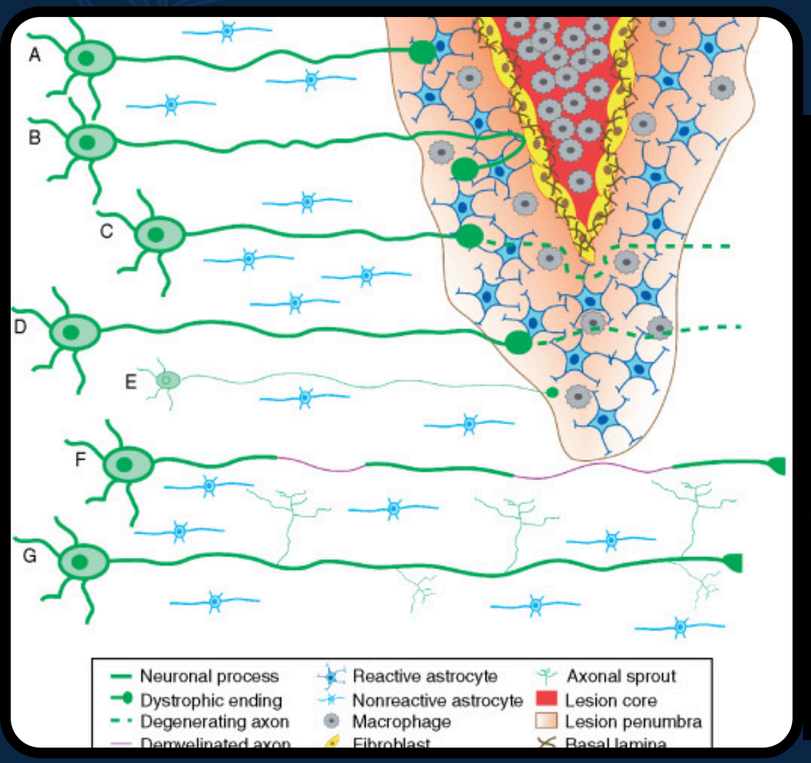


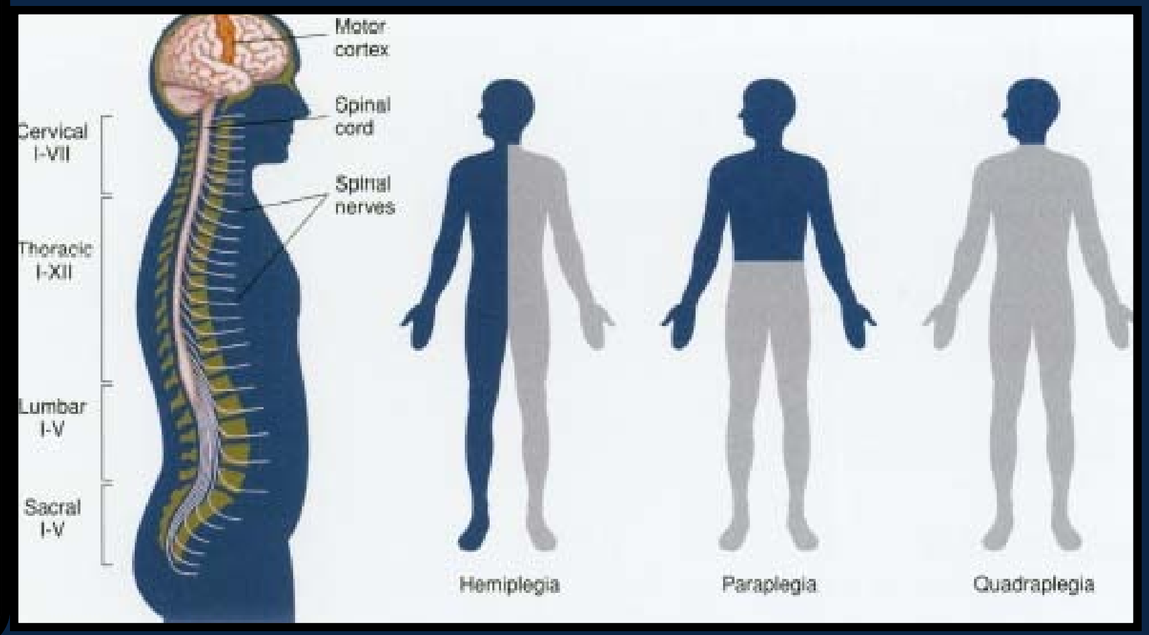




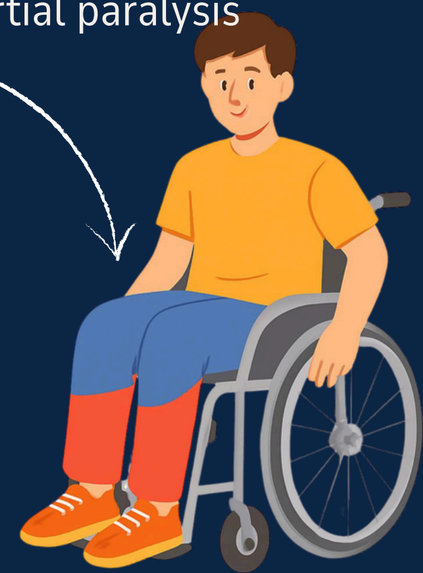
What is Paraplegia?

- Results when severed axons and glial scars block neural signals, and myelin loss further weakens transmission
- Causes loss of movement and sensation below the injury site.



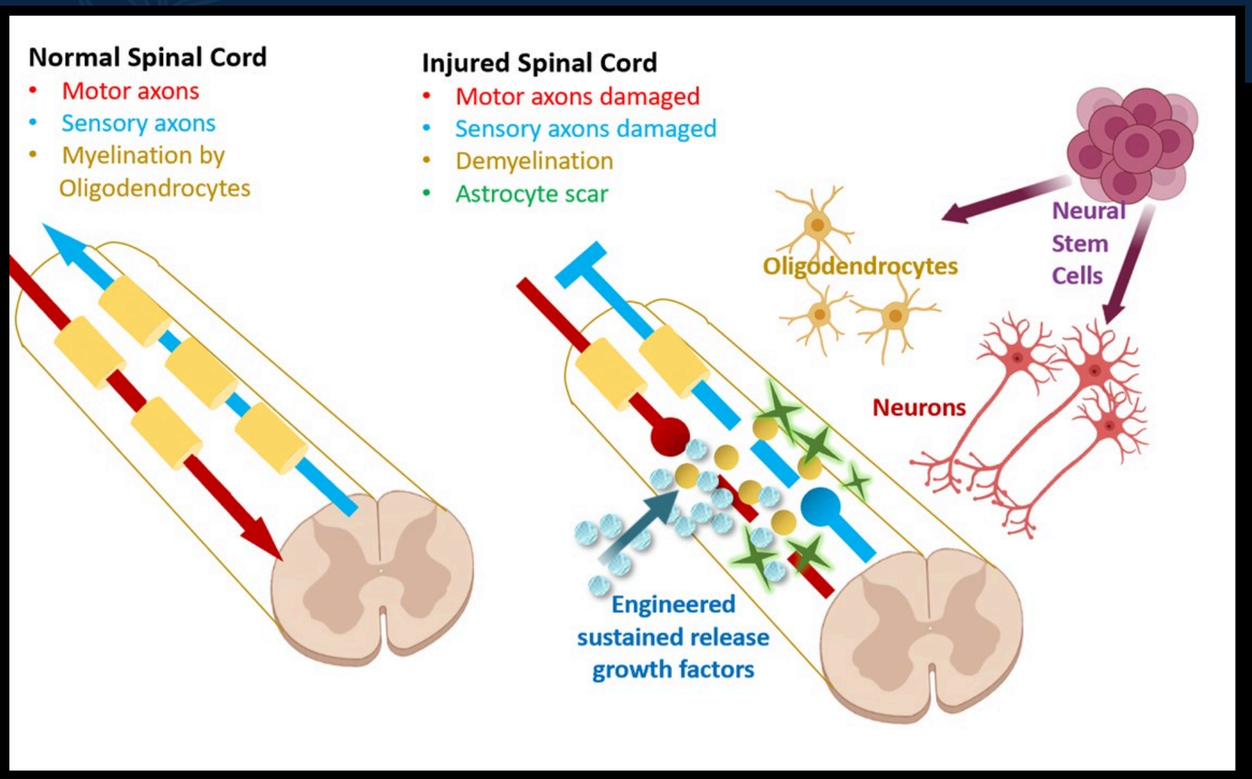


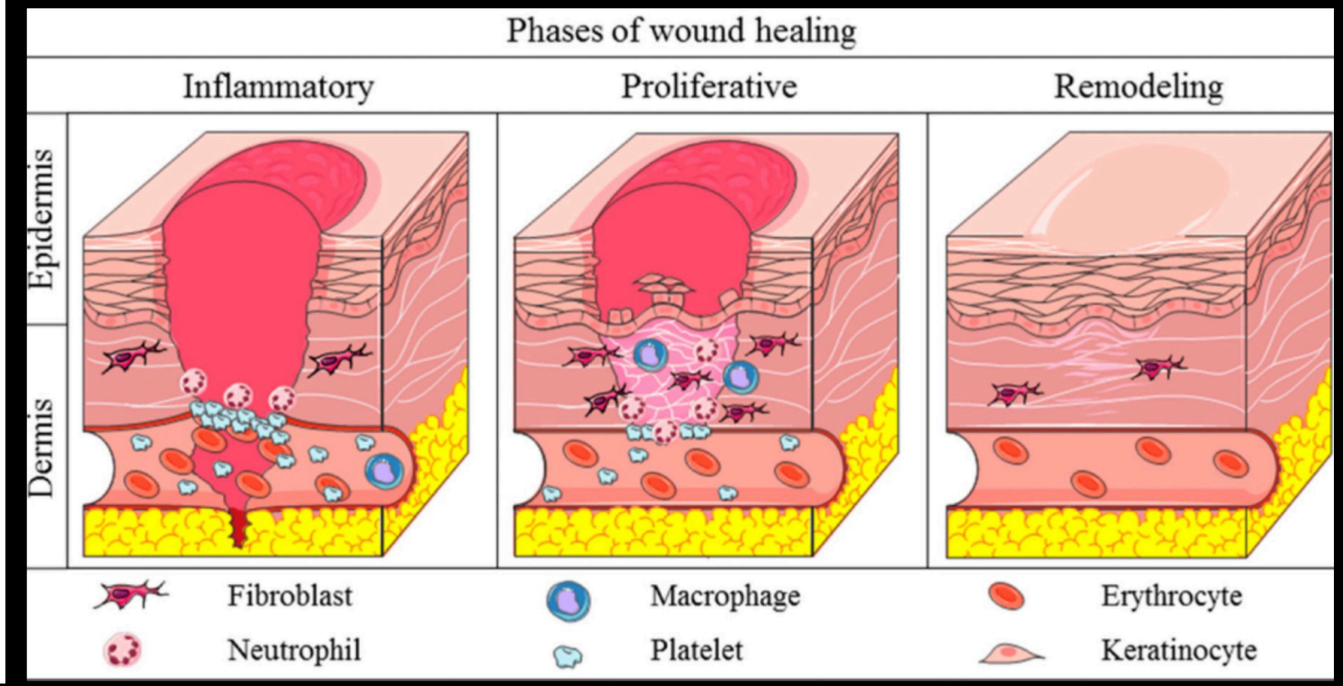
Area of partial paralysis



Healing Challenges?

Spinal cord healing prioritizes containment, as glial scars block axon regrowth, making structural repair alone insufficient for functional recovery.





Concept: “Dancing Molecules”

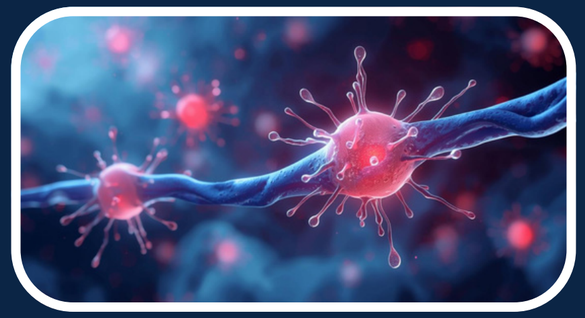
Unlike skin or muscle, spinal cord repair prioritizes containment over reconnection, as glial scar formation during healing blocks axon regrowth, making structural repair alone insufficient to restore neural function.

Molecular Movement

Molecules vibrate to enhance cellular interactions.

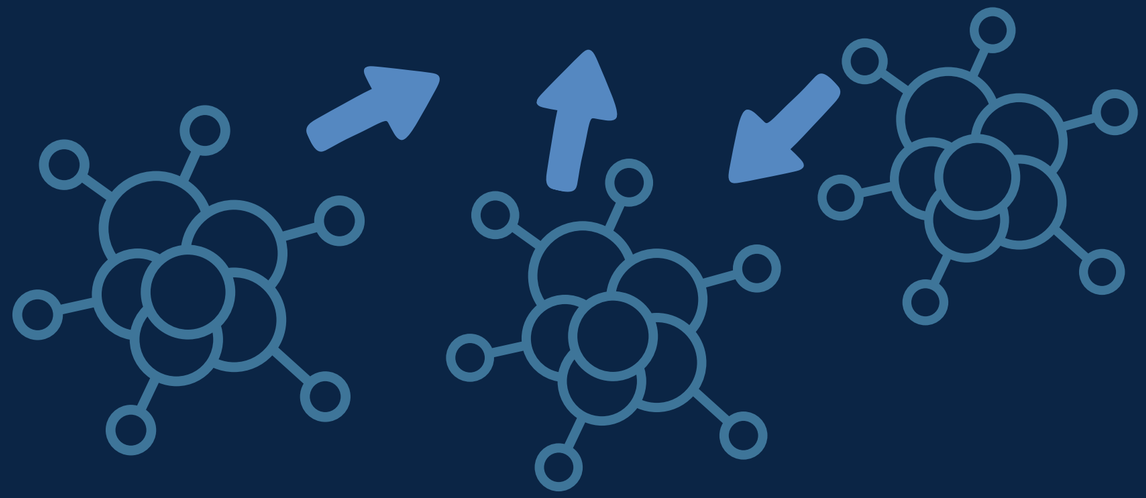
Enhanced Connectivity

Increased interactions lead to improved tissue repair.



Research Impact

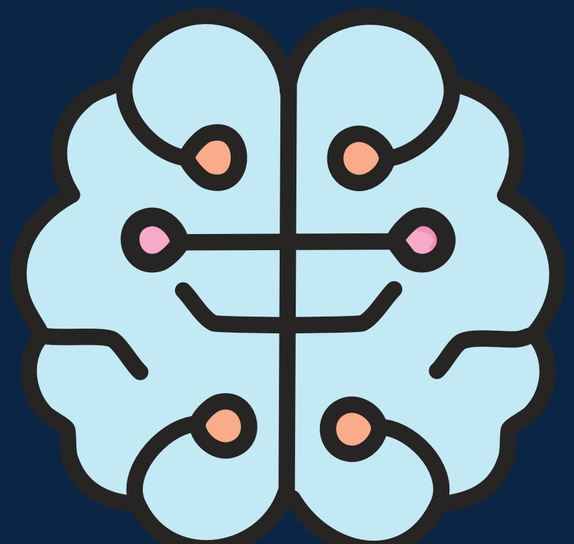
Research from Northwestern University drives advancements forward.

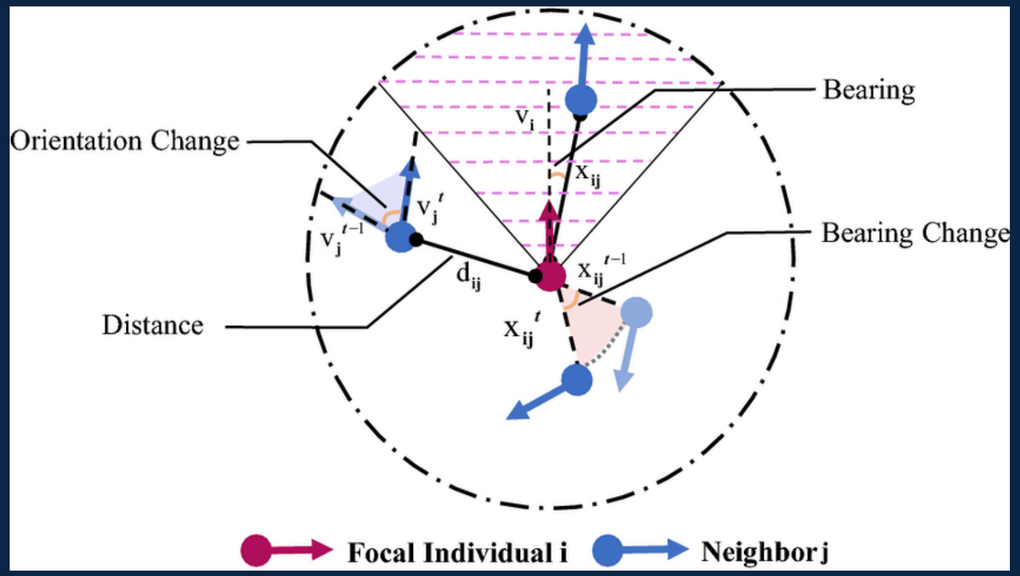


Main Idea

Movement Increases Interactions

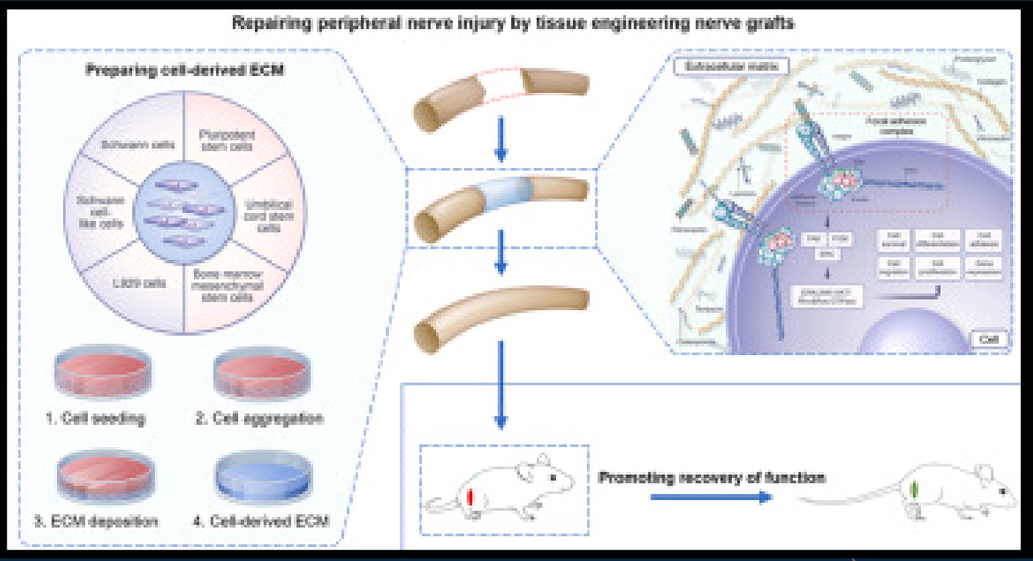
Moving Structures=Better Self-Alignment

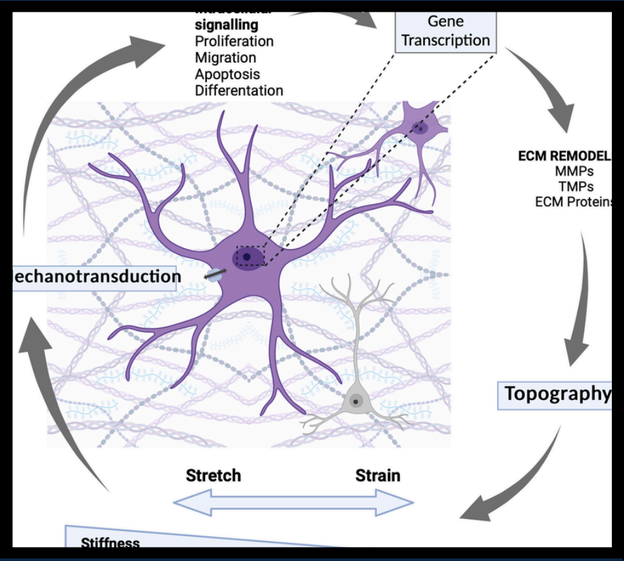


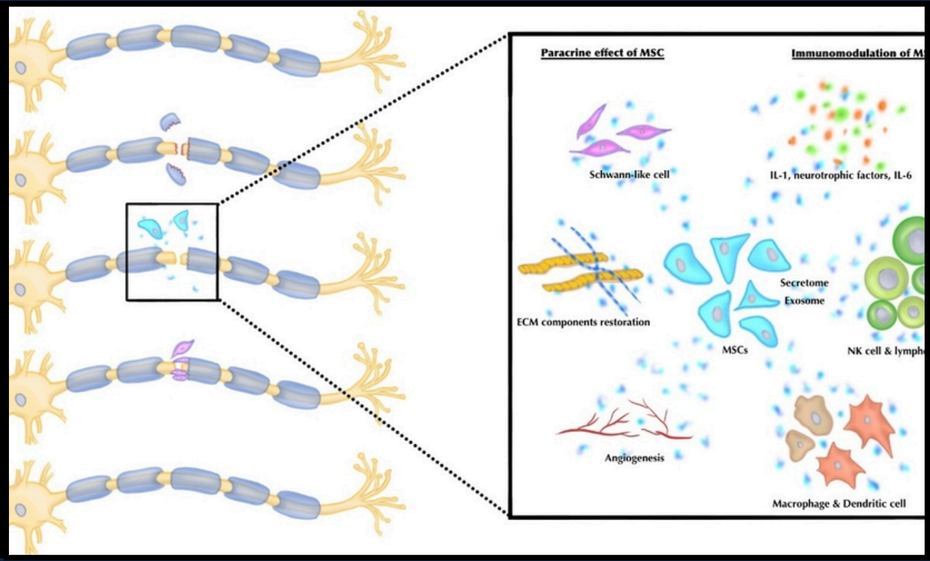


Healing is Dynamic.

Proteins and ECM fibers constantly move, increasing collisions that drive binding, signaling, and reorganization—processes missing in static scaffolds.



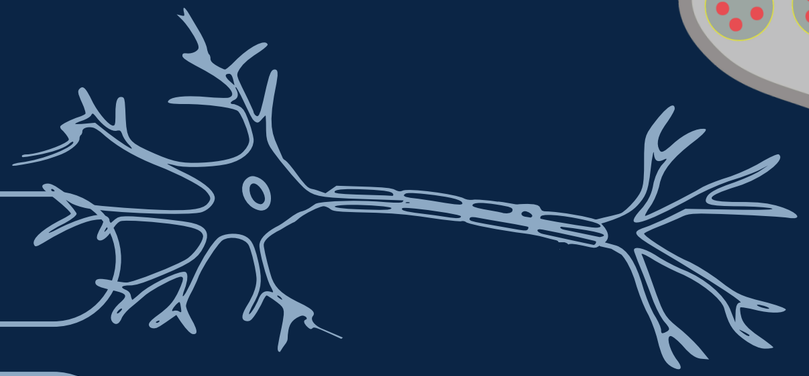
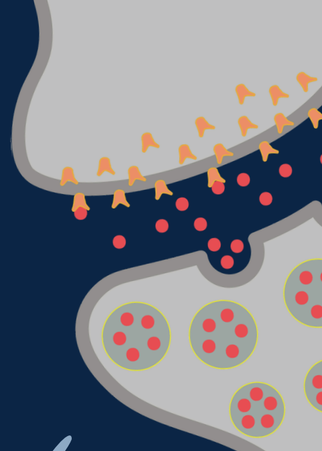
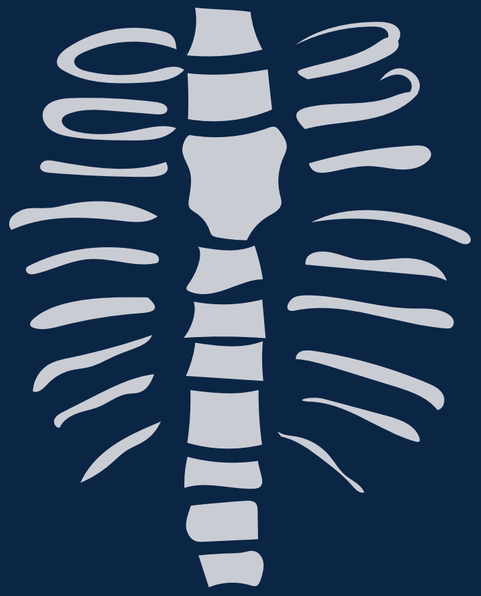
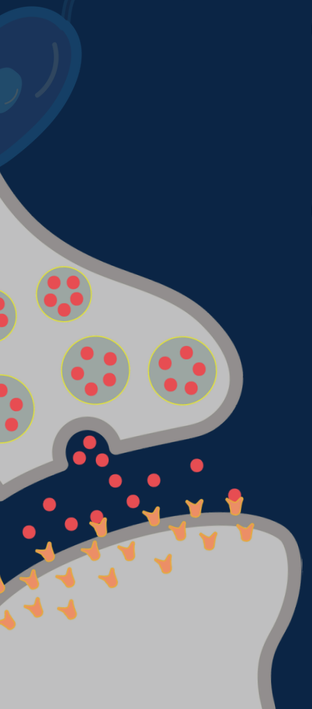




Hypothesis

We hypothesized that internal dynamic motion would:

1. Increase interaction frequency
2. Improve Spatial Coverage
3. Enhance alignment recovery

Testing Motion as an Independent Variable

Independent Variable

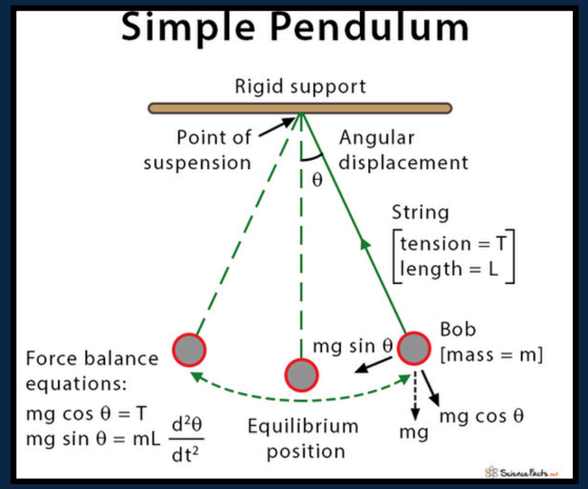
"Motion"

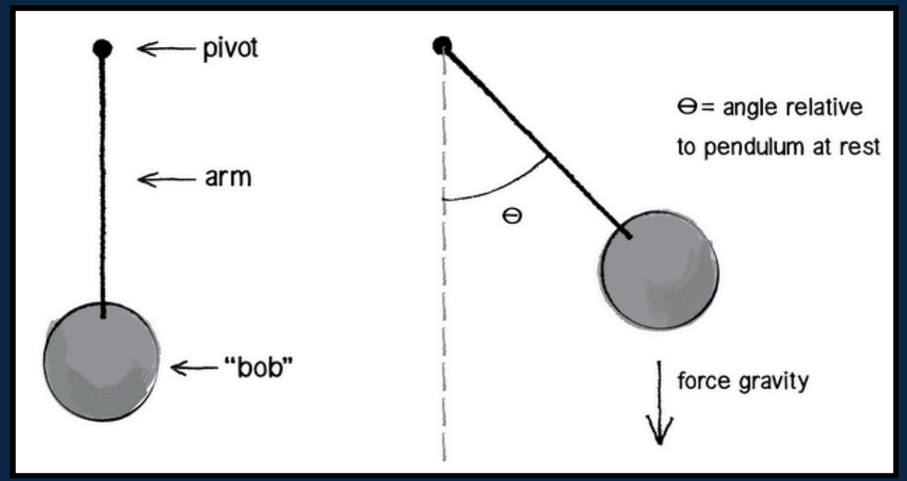
Controlled

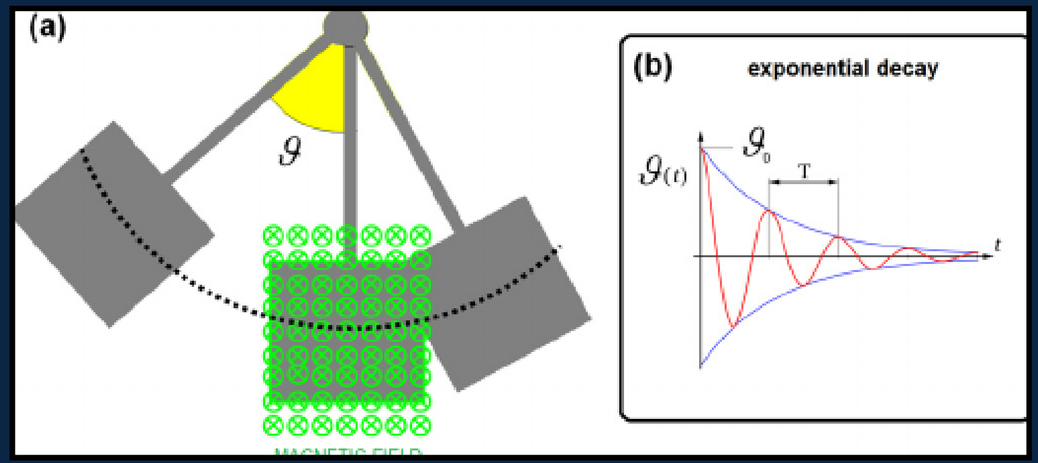
- Initial Pendulum Position
- Congruent Durations
- Same Magnetic strength, & location.

Responding

- Frequency of interactions with receptor zone.
- Spatial coverage of receptor surface.
- Alignment recovery after displacement.





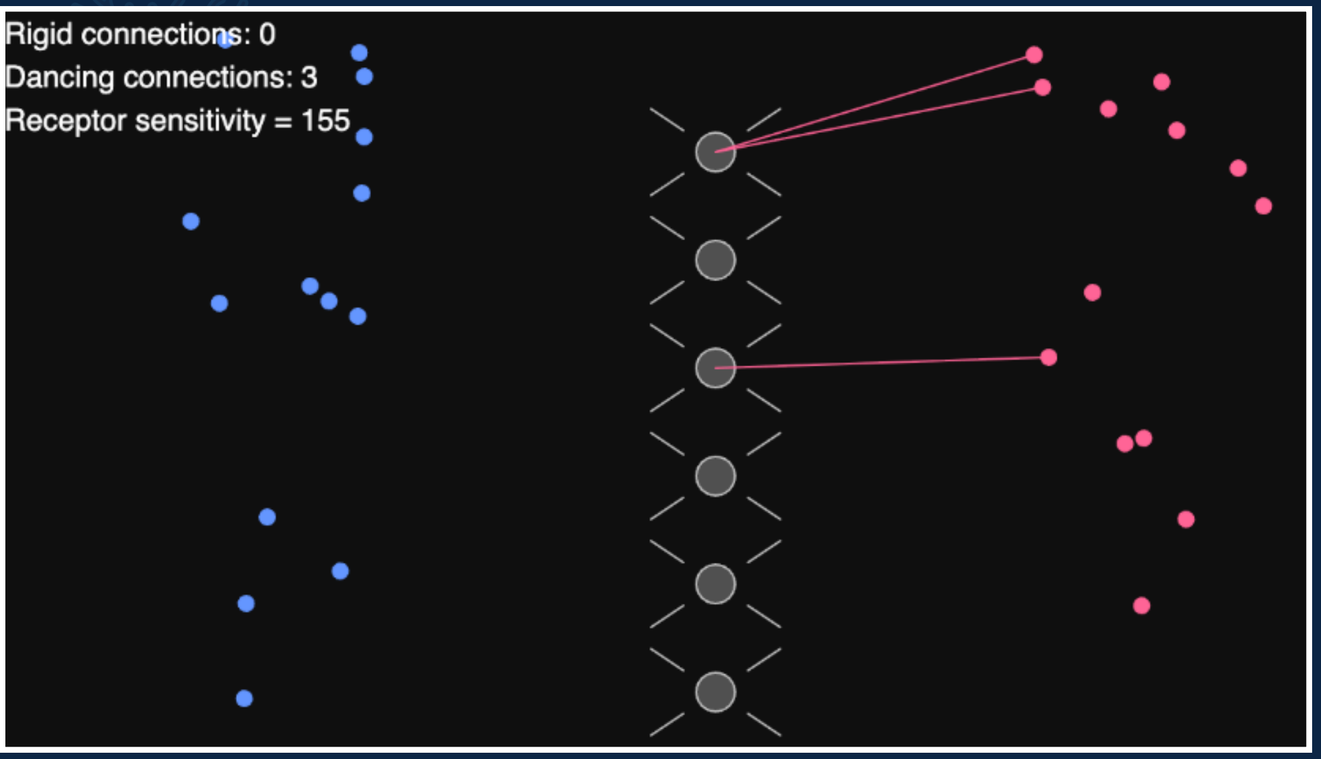


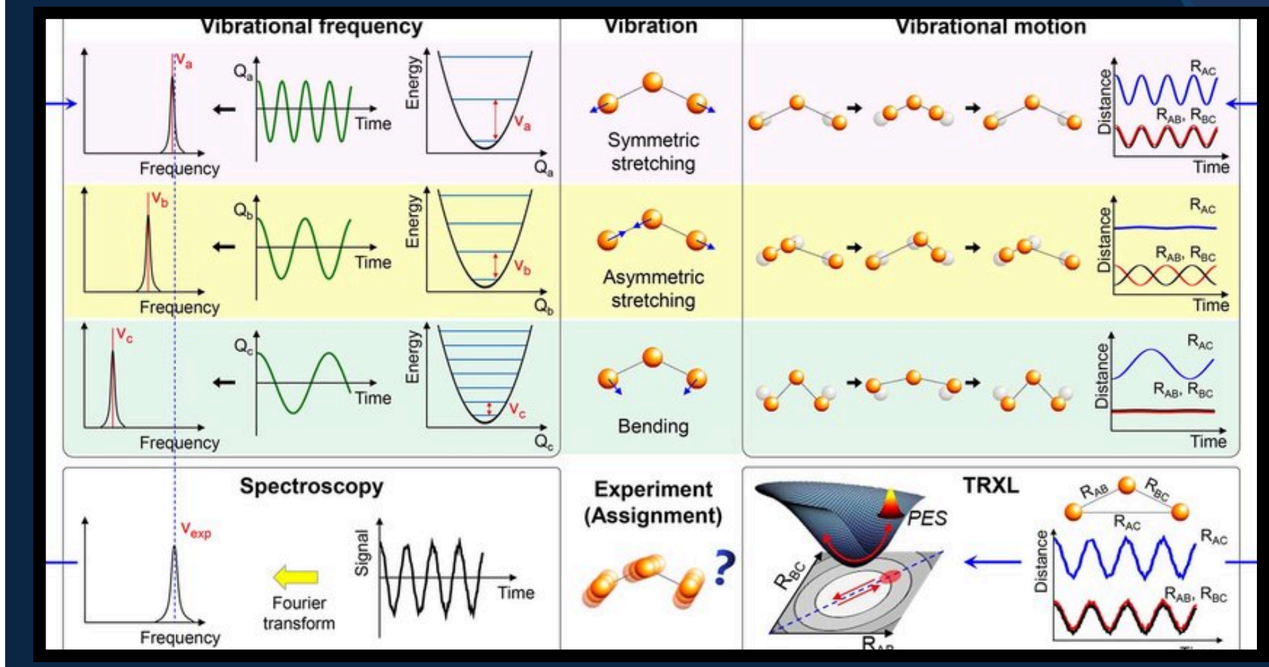
Mechanical Analog of Dynamic Motion

We created a pendulum model to isolate motion: rigid = static, double-jointed = dynamic, magnetic zone = receptor site.

Dynamic Motion Enhances Performance.

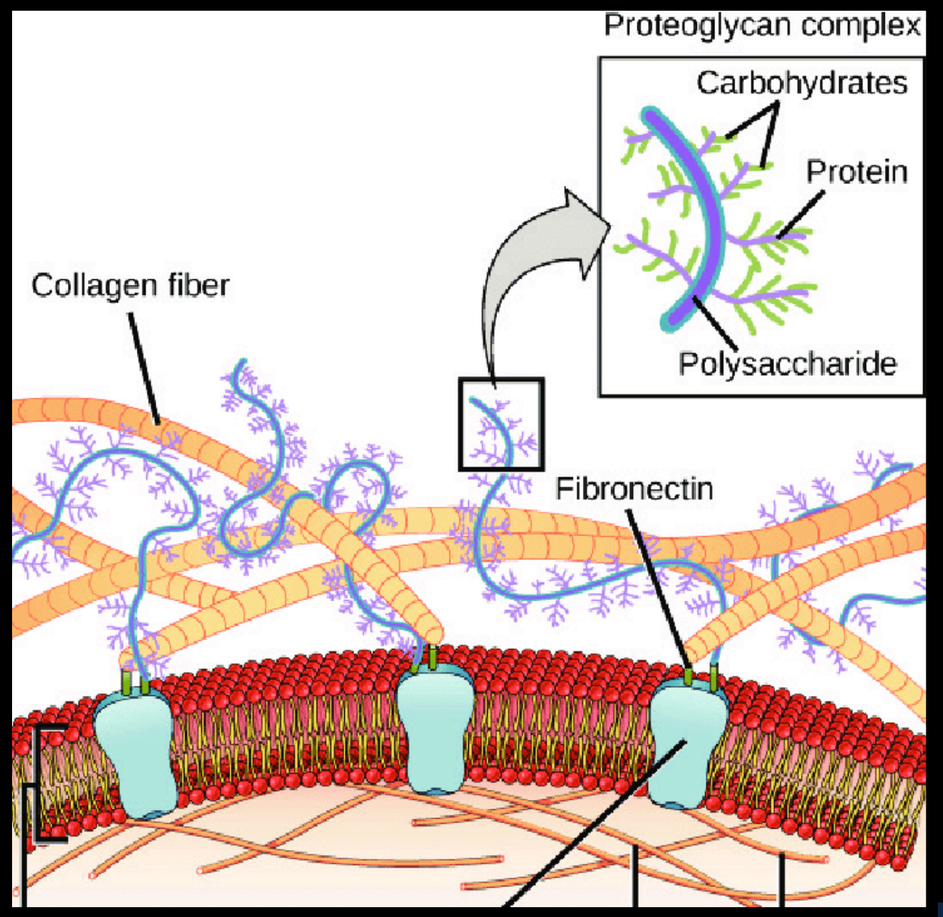
Dynamic pendulums show higher interactions, broader coverage, and self-correcting alignment compared to static pendulums.

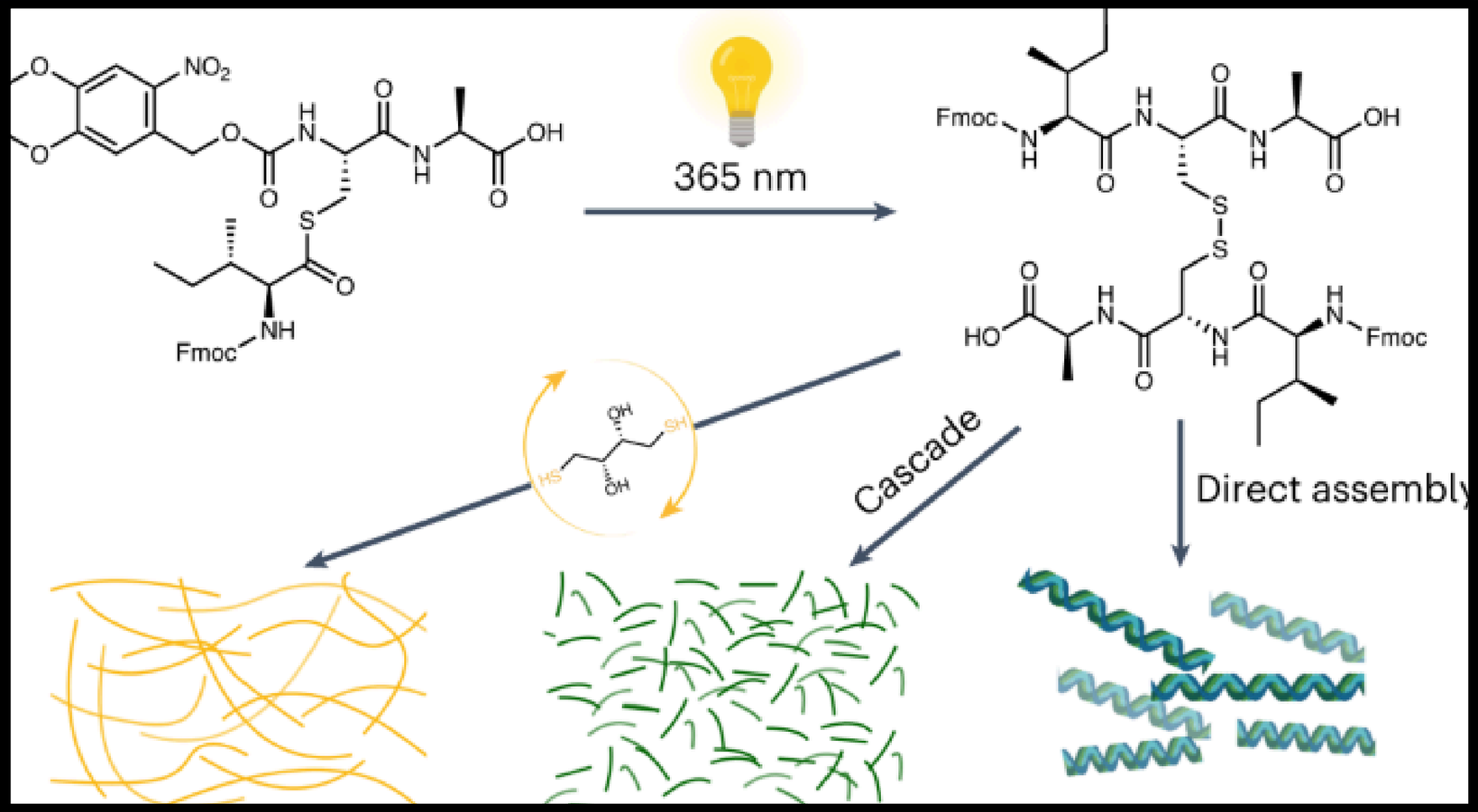




Why Motion matters?

Motion drives interactions and alignment, reflecting natural regenerative behaviour.

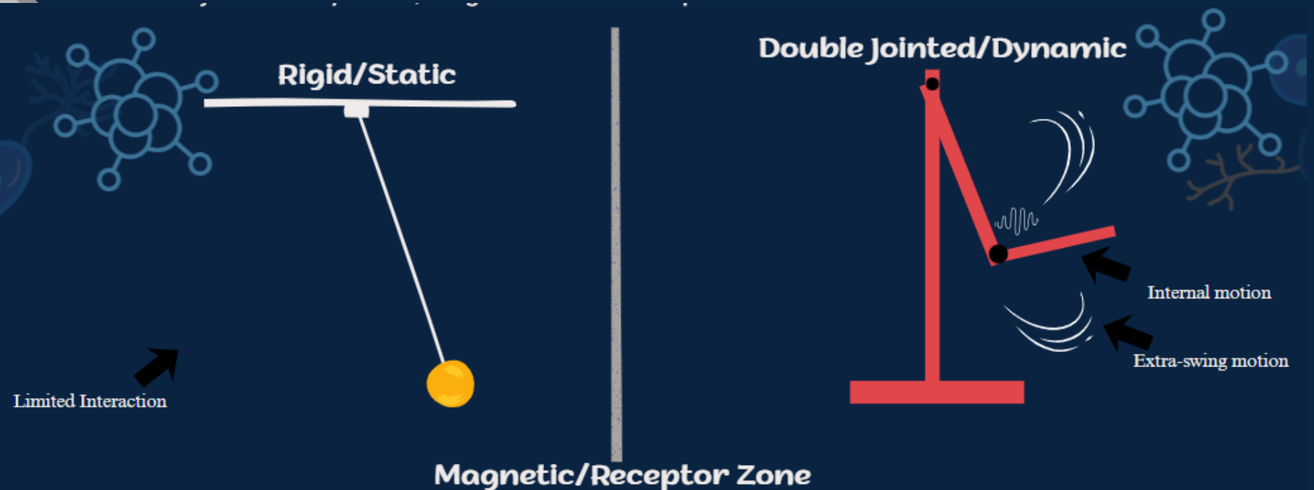




Scope & Limitations

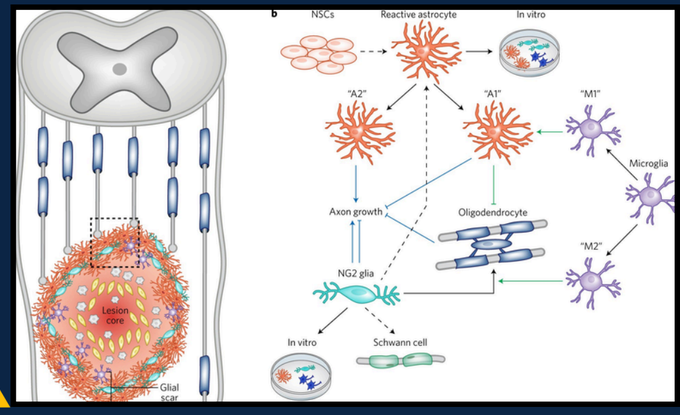
Scope

- Mechanical Analog for motion
- Comparison of static vs dynamic
- Measures: Interaction frequency, spatial coverage, & alignment.



Limitations

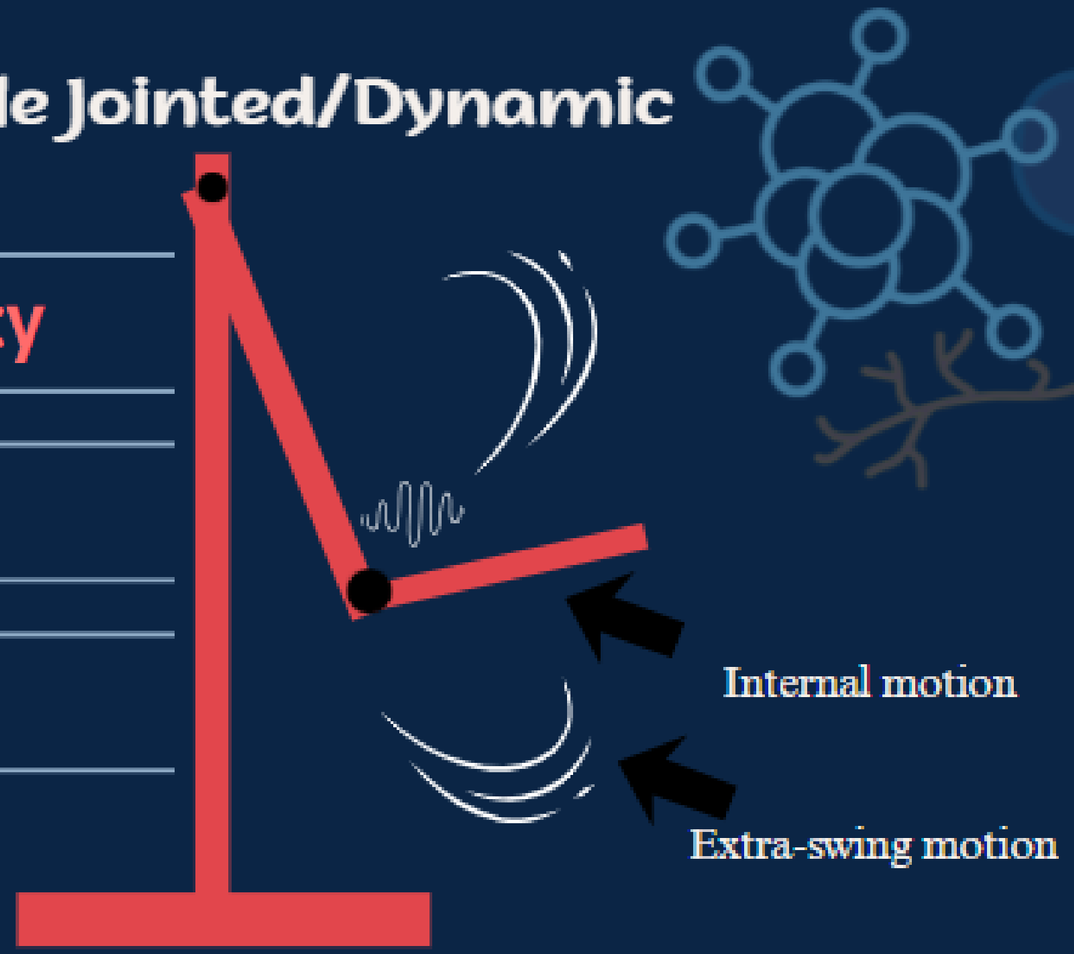
- Macroscopic-level, not molecular scale
- Does not replicate biochemical, electrical, or immune processes.
- Glial Scar signaling is not included.
- Proof for concept only-not a therapy.



Our Contribution.

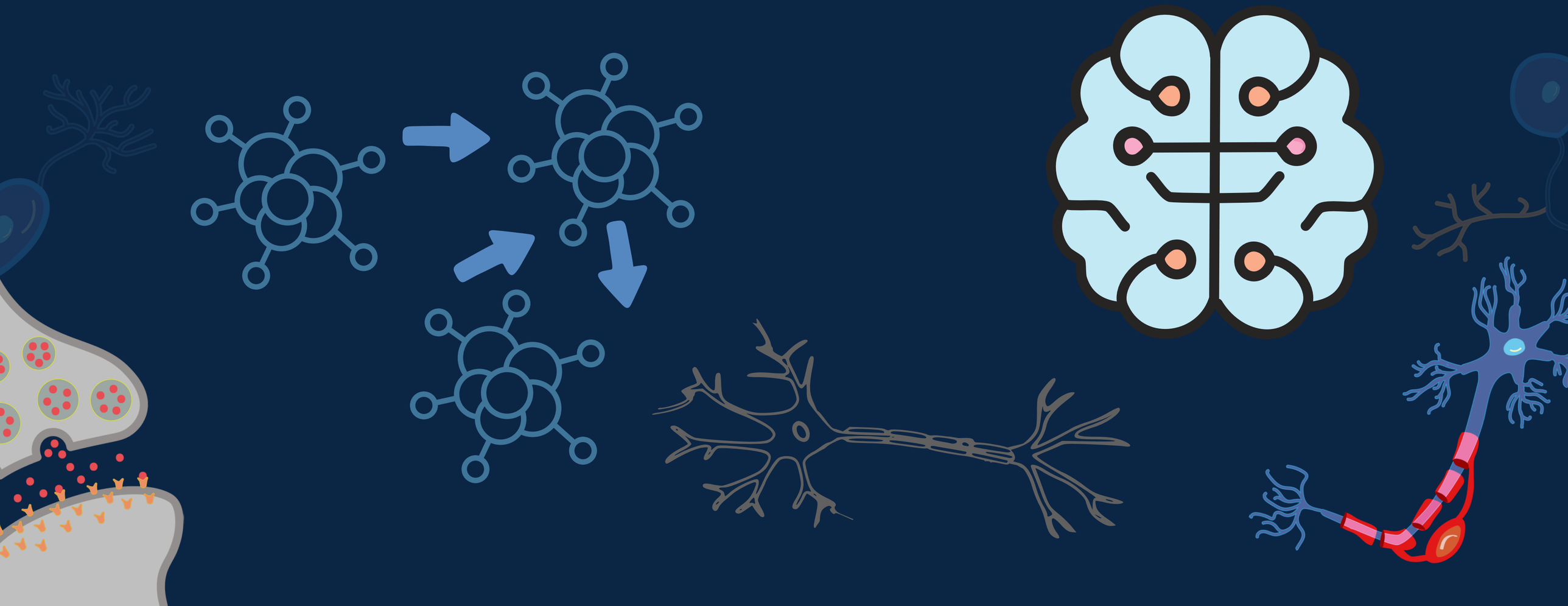
We show that motion enhances interactions and alignment, introducing behavior as a design variable in regenerative scaffolds.

1. Increase interaction frequency
2. Improve Spatial Coverage
3. Enhance alignment recovery



Key Takeaways

Internal motion enhances scaffold performance and should be treated as a design parameter.




Thank You