

# Microcontact Printing of Poly (L-lysine) Using PDMS Stamps for the Adhesion and Patterning of Neurons



UC SANTA BARBARA  
**engineering**



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# Neurological Disorders

The World Health Organization (WHO, 2007):

-One *billion* people suffer from some form of ND

-Europe spent *\$194 million* in 2004 alone on palliative care

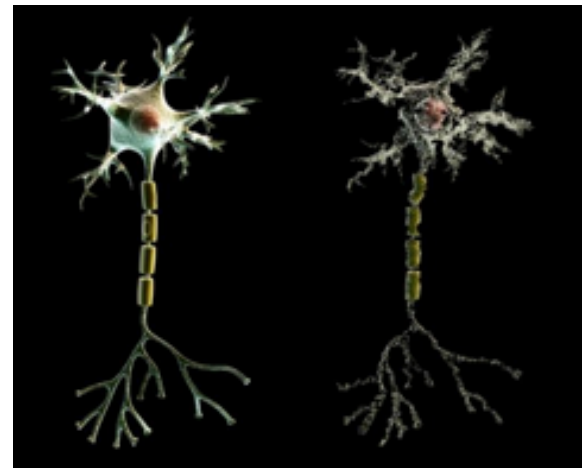
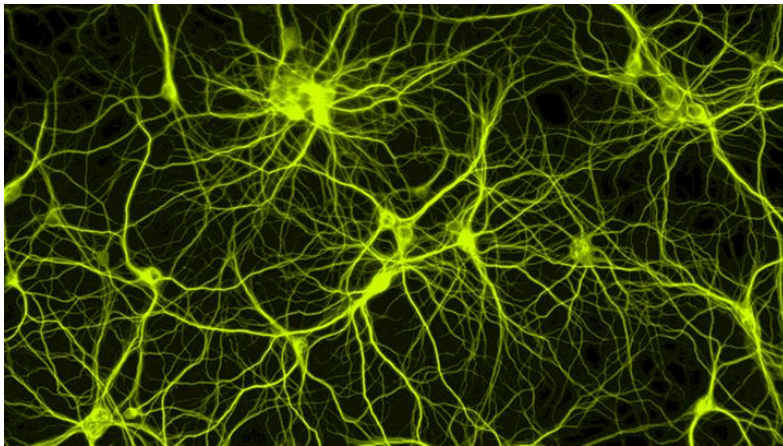
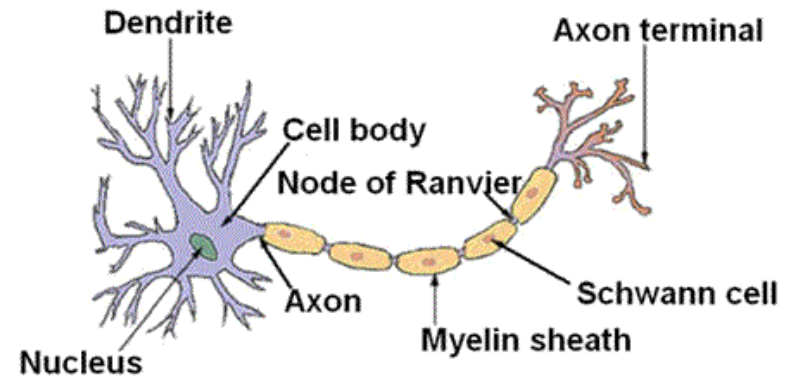
-Effective care is largely unavailable to many suffering with NDs



-Billions of brain cells = neural network (1 neuron ~ 10  $\mu\text{m}$  wide)

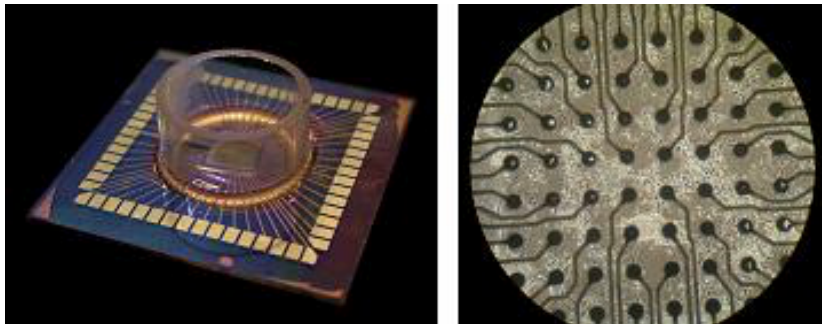
-Send and receive info via electrochemical signals

-Neurons comprise who we *are*.

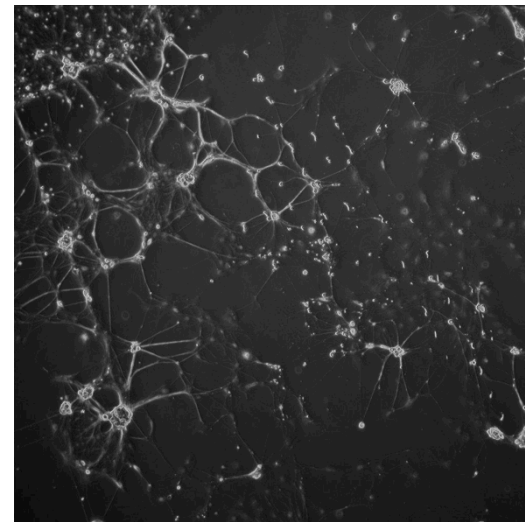


## Research goals for this summer include:

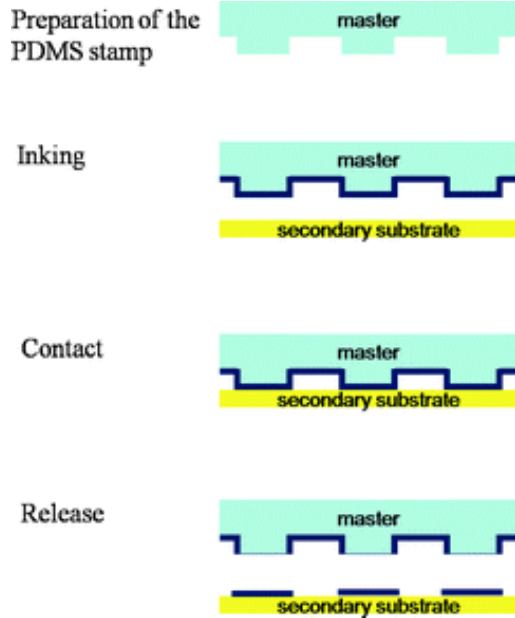
Create a novel, reproducible method of patterning healthy rat neurons onto glass substrates and multi electrode arrays (MEAs)



Incubate neurons and record neurite growth

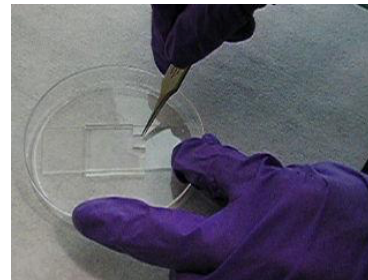
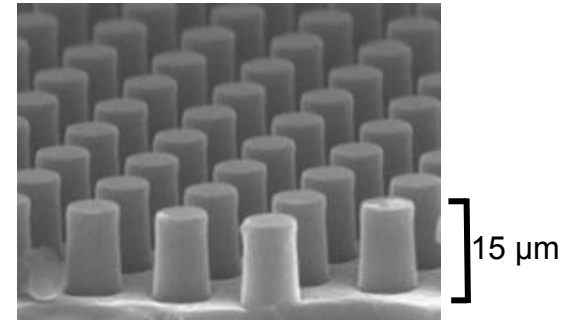


# Experimentation

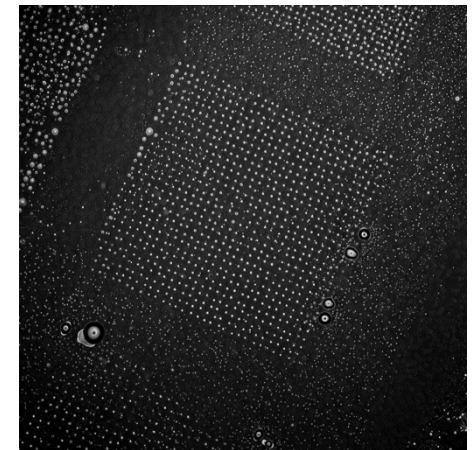


“Ink” = Poly (L-lysine) (PLL), a positive, hydrophilic polymer to promote neuron adherence

## Polydimethylsiloxane (PDMS) Stamp

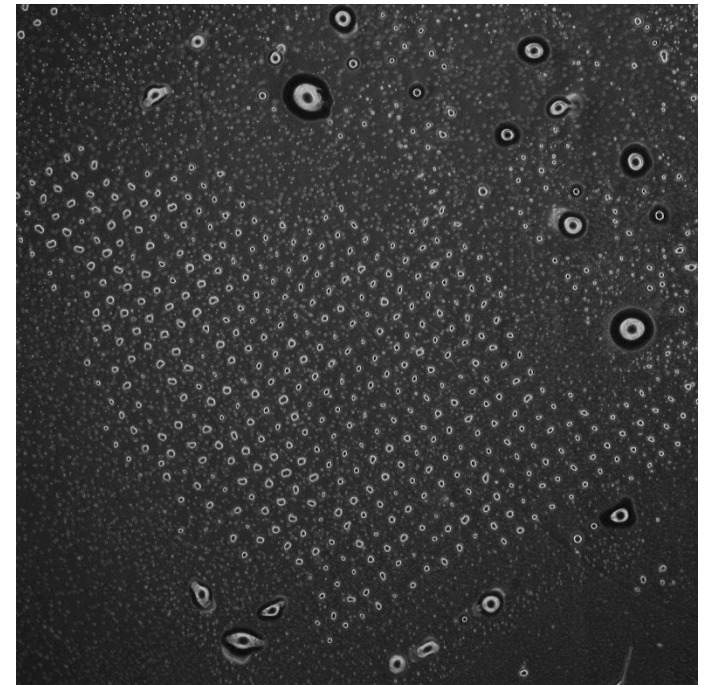
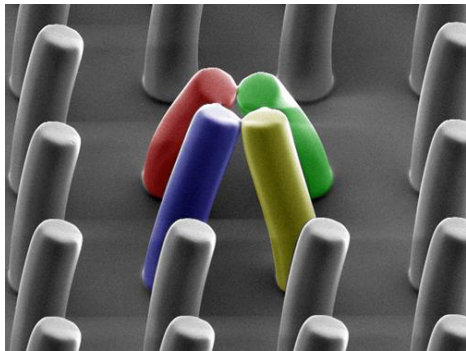


Force →



# Experimental Problems

Pillar deformation when non-uniform or excessive force applied to stamp



# Experimental Solutions

$$E = \frac{\sigma}{\epsilon}$$

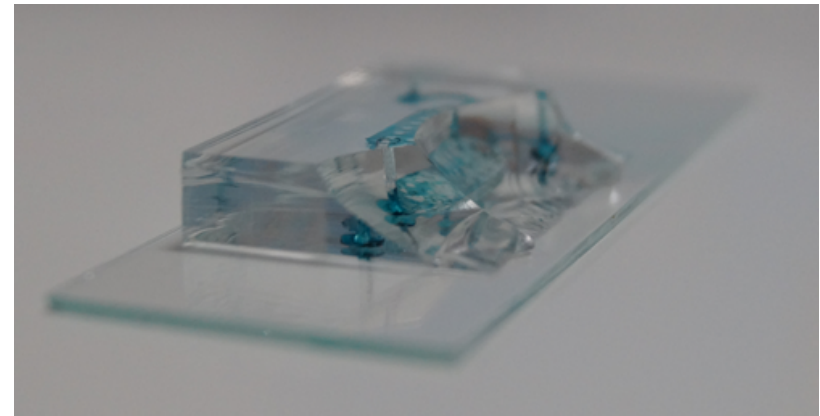
Young's Modulus (Pa)      Stress (Pa)  
Strain

Young's Modulus (PDMS) ~ 500 kPa

Young's Modulus (Glass) ~ 50 GPa

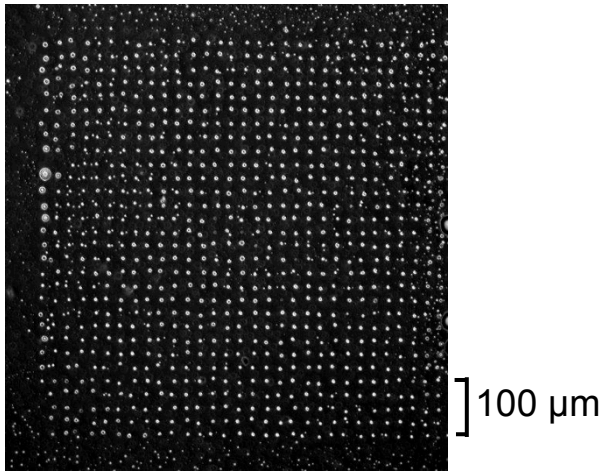
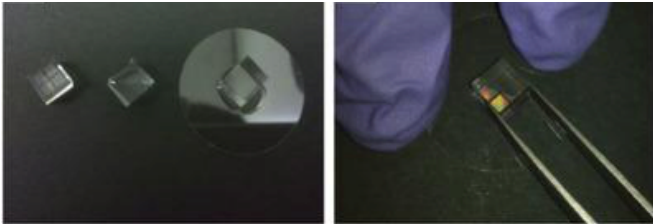
Glass is stiffer than PDMS.

Glass-backed stamp provides more even distribution of force, which may lead to less deformation.

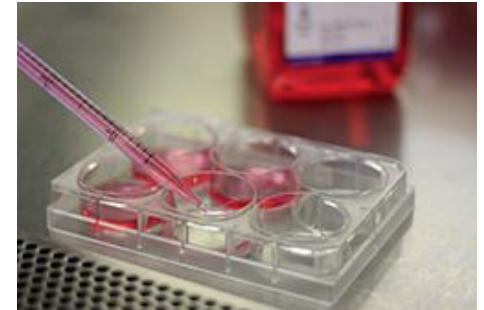


# Neuronal Plating

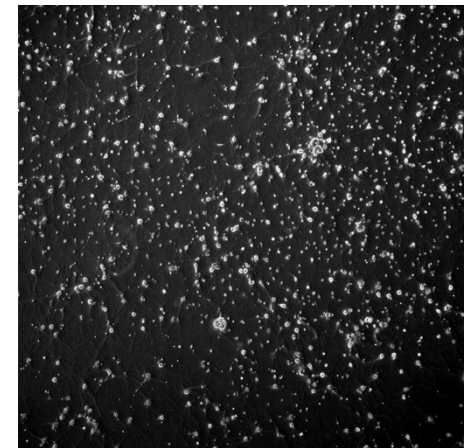
After PDMS stamping...



...stamped substrates were placed in wells and neurons were introduced with media.



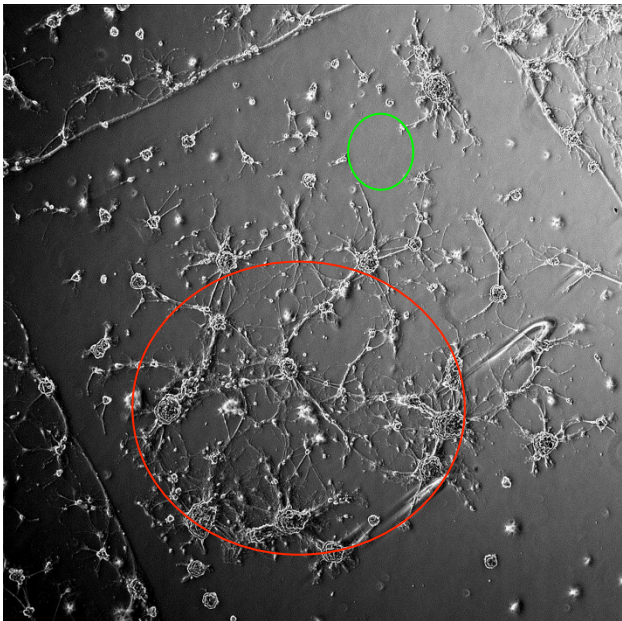
2 ml of media mixed with 100,000 rat hippocampal neurons per well



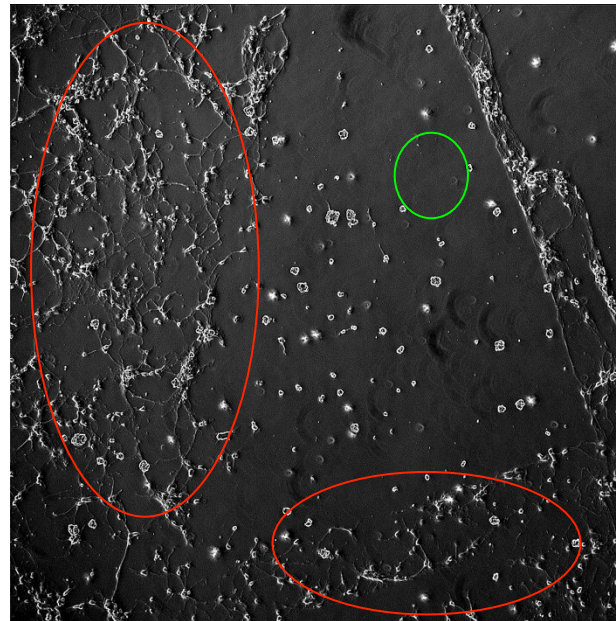


# Following Neurite Growth

25  $\mu\text{m}$  pitch



35  $\mu\text{m}$  pitch

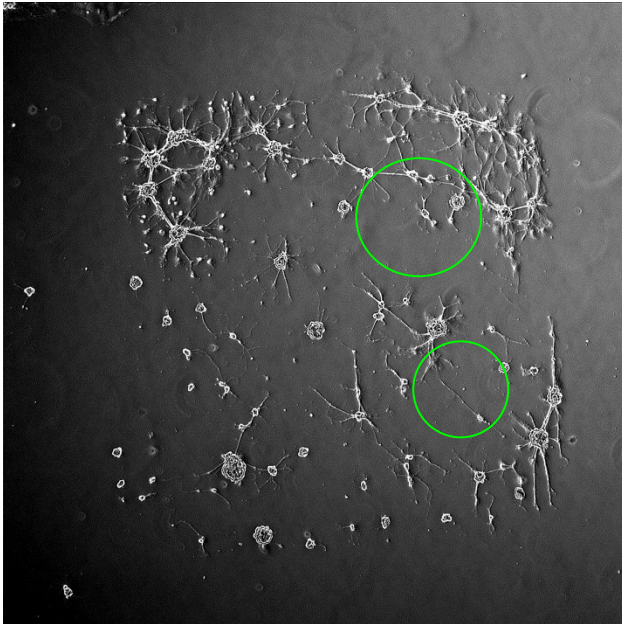


- Large overgrowth areas
- PLL absent areas
- Non-uniform distribution of force causing stamp deformation

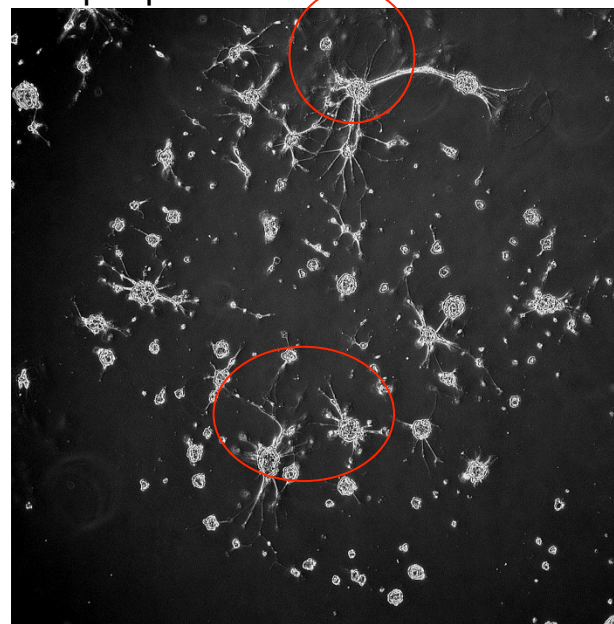
Unmodified PDMS Stamp 9 DIV, force of finger, 0.5 mg/ml PLL

## Neurite Growth Cont...

25  $\mu\text{m}$  pitch



35  $\mu\text{m}$  pitch



-More defined pattern

-Less overgrowth

-“Patchy” neuronal growth

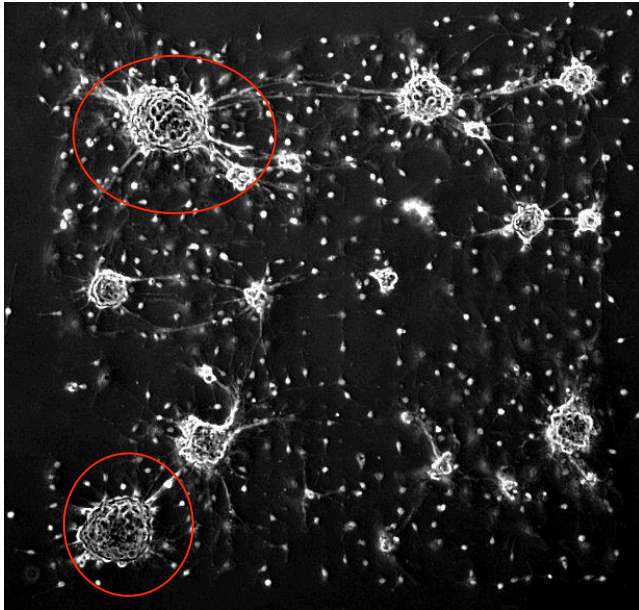
-Neuronal overgrowth still at some PLL spots

-Both indications of pillar deformation

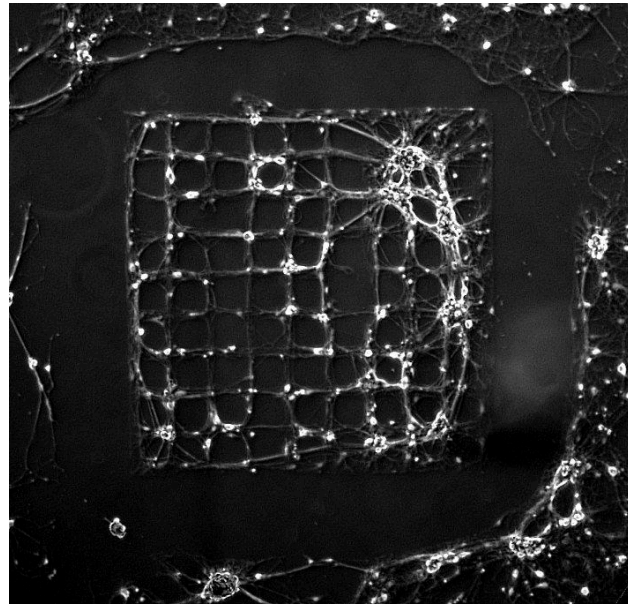
Unmodified PDMS Stamp 12 DIV, 200 gram weight applied, 0.5 mg/ml PLL

# “Window” Neurites

25  $\mu\text{m}$  pitch



Perfect “window” pattern

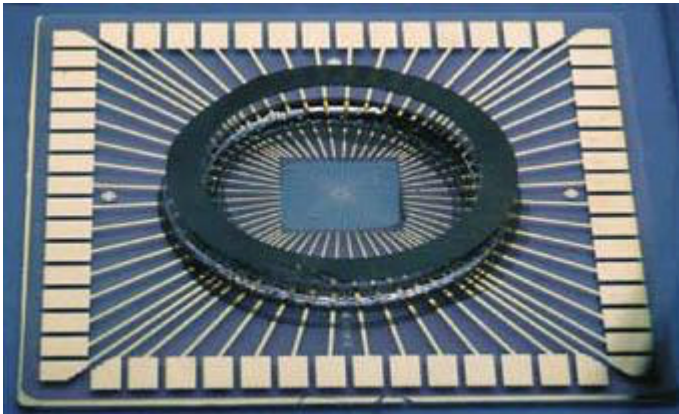


-Still some overgrowth,  
may be due to not  
completely drying  
stamp

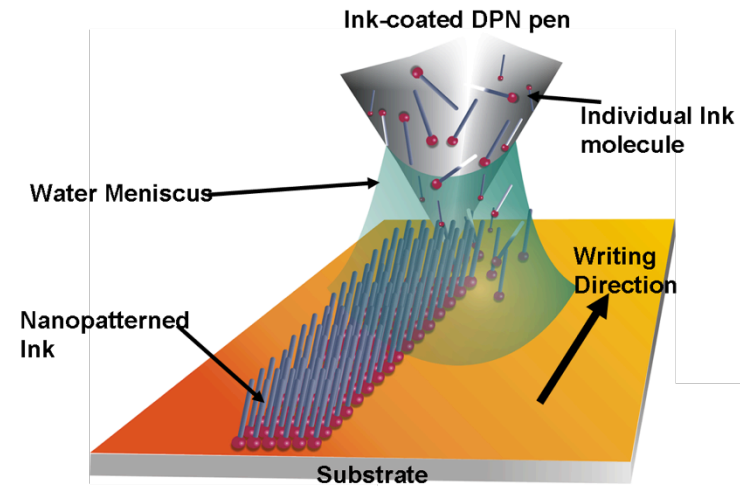
Glass-backed PDMS Stamp 9 DIV, 50 gram weight applied, 0.5 mg/ml PLL

# Continuing the Research

Multielectrode Array recordings of extracellular electrical neurite activity



Using Atomic Force Microscopy for direct deposition of Poly (L-lysine) to make process more reproducible and automated



# Acknowledgements

Mentor: Sarah Grundeen

Advisor: Dr. Luke Theogarajan

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Dedicated to: Cynthia Martello (mom)



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