

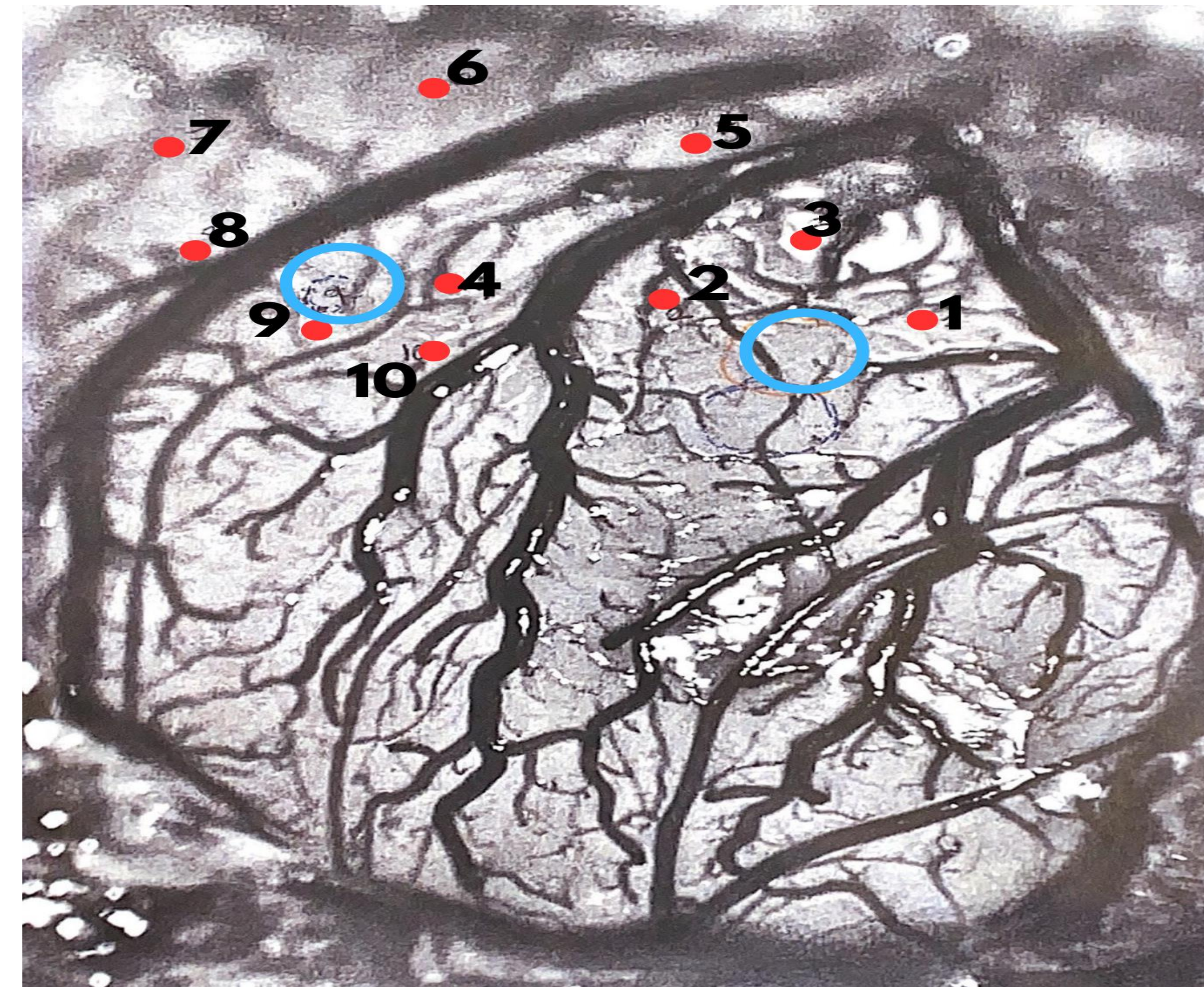
## Introduction

- Our early sensory experiences and ability to explore our environment shapes our brain, perceptions and behavior
- Active exploration provides kinematic and sensory feedback which drives movement that are distributed in neural networks
- Deprivation and unnatural environments effect fine motor precision, manual dexterity, bilateral coordination, balance and motor limb coordination.
- On the contrary, naturalistic environments are key for cognitive function, stress regulation, and motor development
- Our study looks to quantify functional brain organization, motor cortex connectivity, corticospinal tract connectivity and use statistical analysis to correlate/predict neural or behavioral phenotypes that are demonstrated by the environment

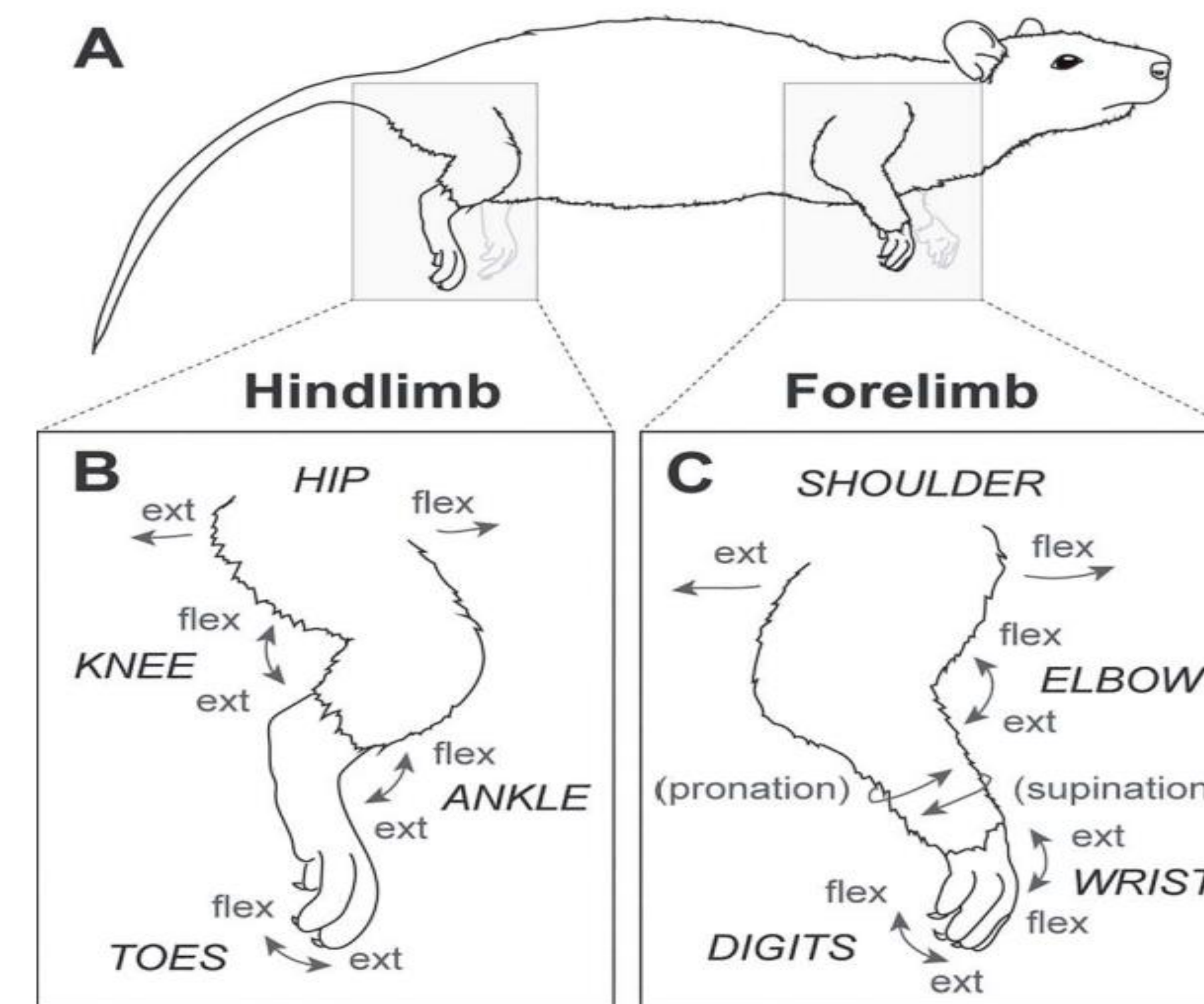
## Control/Hypothesis

- **Control Group:** Norwegian Brown (NB) rats raised from birth in standard laboratory housing [Lab (L) rats]
- **Experimental Group:** NB rats raised in super-enriched, semi-natural environments in outdoor field pens (3000 times larger than standard housing) [Field Pen (FP) rats]
- **Hypothesis:** Environmental and behavioral differences will correlate with differences in intrinsic connections of M1, specifically the corticospinal tract

## Design/Methodology



**Figure 2.** Annotated pictures of a rat brain during a survival surgery – post craniotomy and durotomy. (A) Red Circles: Sites of Intracortical Stimulation (B) Blue circles: Injection Sites of Neuroanatomical tracers



**Figure 3.** Visual Representation of Forelimb and Hindlimb movements which were evoked during ICMS mapping. Data Source: (Drew et al, 2020)

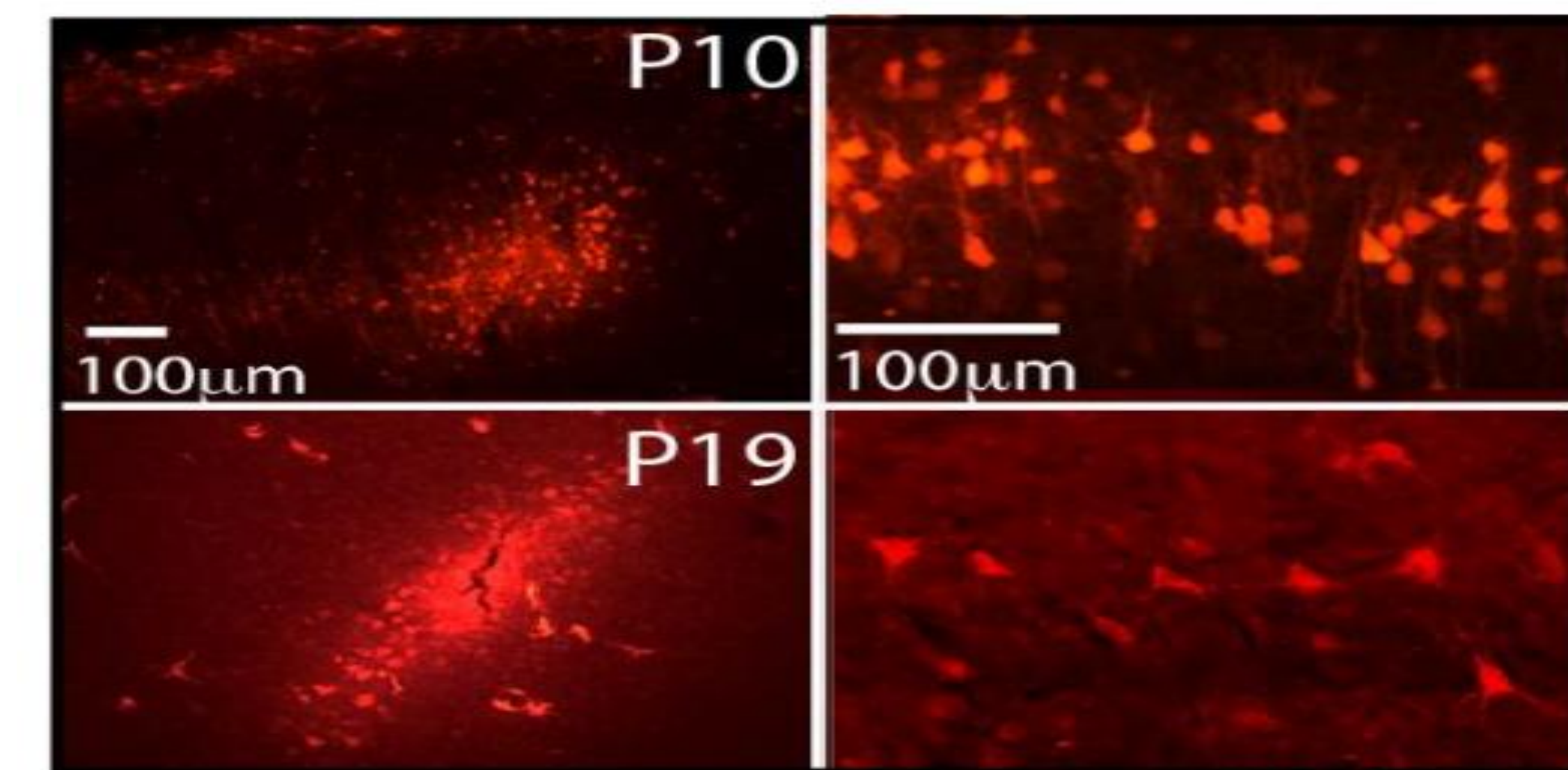
## Preliminary Results

Intracortical Microsimulation Brain Map								
Site #	Depth (µm)	Voltage (mA)	Evoked Movements	Hindlimb	Forelimb	Torso	Head/Face	Tail
1	1,200	300	<ul style="list-style-type: none"> <li>• Ankle Movement</li> <li>• Toe Movement</li> </ul>	X				
2	1,200	300	<ul style="list-style-type: none"> <li>• Leg Movement</li> <li>• Arm Movement</li> <li>• Tail Movement</li> <li>• Torso Movement</li> </ul>	X	X	X		X
3	1,200	500	<ul style="list-style-type: none"> <li>• Hip Flexion</li> </ul>	X				
4	1,200	500	<ul style="list-style-type: none"> <li>• NCM</li> </ul>					
5	1,200	300	<ul style="list-style-type: none"> <li>• Arm Movement</li> <li>• Leg Movement</li> <li>• Torso Movement</li> </ul>	X	X	X		
6	1,200	300	<ul style="list-style-type: none"> <li>• Whisker Movement</li> </ul>				X	
7	1,200	500	<ul style="list-style-type: none"> <li>• Whisker Movement</li> <li>• Torso Movement</li> </ul>			X	X	
8	1,200	300	<ul style="list-style-type: none"> <li>• Shoulder Abduction</li> <li>• Wrist Extension</li> </ul>		X			
9	1,200	300	<ul style="list-style-type: none"> <li>• Elbow Flexion</li> </ul>		X			
10	1,200	300	<ul style="list-style-type: none"> <li>• Elbow Flexion</li> </ul>		X			

**Table 1.** Description of the intracortical microsimulation experimental outcomes. 10 sites were stimulated at a depth of 1,200 µm with evoked responses resulting from voltages ranging from 300 – 500 mA. Examples of evoked Movements are visually represented in Figure 3. and during the experiment encompassed movements in the hindlimb, forelimb, torso, head/face and tail.

## Design/Analysis

- 1.) Motor Maps will be generated via Intracortical Microsimulation (ICMS), generating functional movement representation in M1 & allow for precision of neuroanatomical tracers and connections
- 2.) Small volumes (0.02-0.05 µl) of fast neuroanatomical transport tracers (Fluro-ruby (FR) or Cholera Toxin B (CTB) will be injected in desired motor representations via survival surgery
- 3.) After retrograde transport of the tracers (6-8 days) the spinal Cord will be sectioned horizontally and mounted for fluorescent microscopy
- 4.) Retrogradely labeled cells of the corticospinal tract will be plotted using X/Y stage encoding and the connections will be quantified



**Figure 4.** Examples of injections and cells retrogradely labeled with Fluro-ruby

## Conclusions/Further Study

- We are the first to rear rats in housing 3,000 times larger than standard housing providing insight into how environmental design can impact future studies in neuroscience
- We expect FP rats to evoke more complex, multi-joint movements of the hindlimb/tail, more evoked synergies of the hindlimb and forelimb over a large region of cortex, and novel evoked synergies.
- We expect corticospinal axons from forelimb, hindlimb and tail representations in cortex will project over a larger number of spinal segments in FP rats compared to L rats.
- Our study provides insight into how early environment effects neurodevelopment and organization – highlighting the potential need for early environmental interventions in patients with congenital neurological disease and children in underserved communities

## References

1. Halley, Andrew C., et al. "Distributed motor control of limb movements in rat motor and somatosensory cortex: the sensorimotor amalgam revisited." *Cerebral Cortex* 30.12 (2020): 6296-6312.
2. Seelke, Adele MH, et al. "Individual differences in cortical connections of somatosensory cortex are associated with parental rearing style in prairie voles (*Microtus ochrogaster*)." *Journal of Comparative Neurology* 524.3 (2016): 564-577.

## Acknowledgements

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**Figure 1.** (A) Aerial view of field pens (B) Depiction of field pens near Putah Creek Riparian Reserve Field (Dimensions: 9.75 x 2.5 x 2.5 m). (C) View inside the field pens and the rats nest box (D) View inside the nest boxes where the rats typically sleep (E-G) Depictions of the rats maneuvering around the field pen, performing complex movements and behaviors. These field pens are open to natural weather (e.g. 12 – 44°C; 4–100% humidity), day/night length and sun/moon light