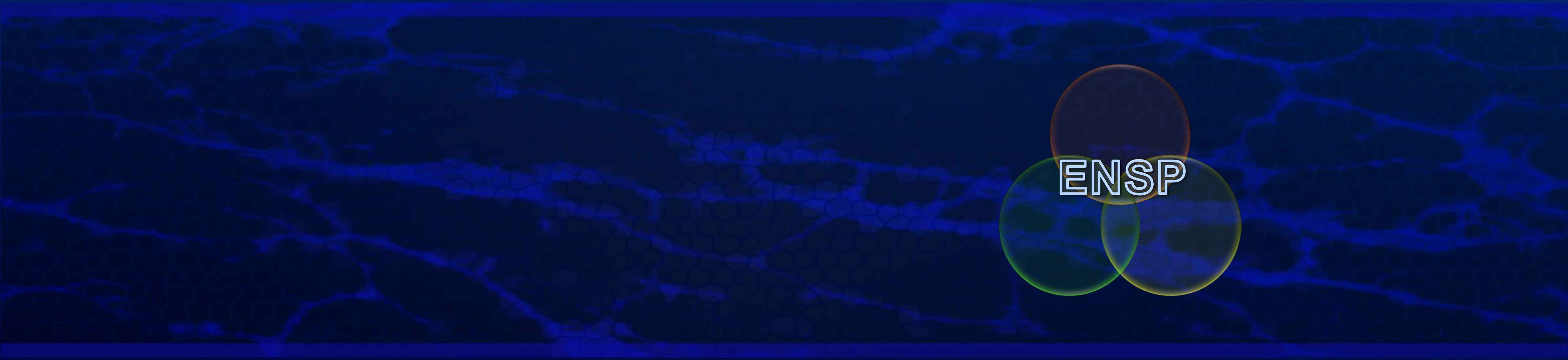
Breakout Session 7: Track A

Developing Computational Tools to Analyze the Structure of Nerve Cells in the Bowel to Better Understand Digestive Disease

Neurobiology of Intrinsic Afferent Neurons

Developing computational tools to analyze the structure of nerve cells in the bowel to better understand digestive disease

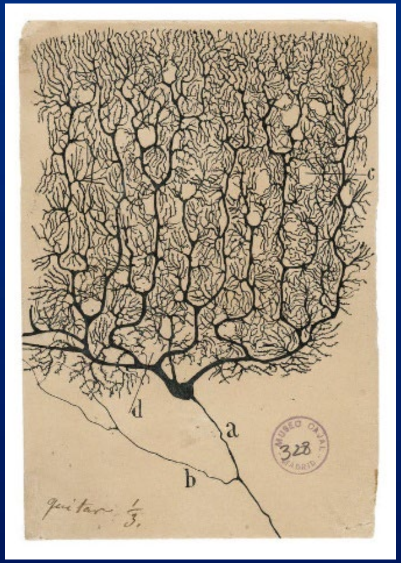
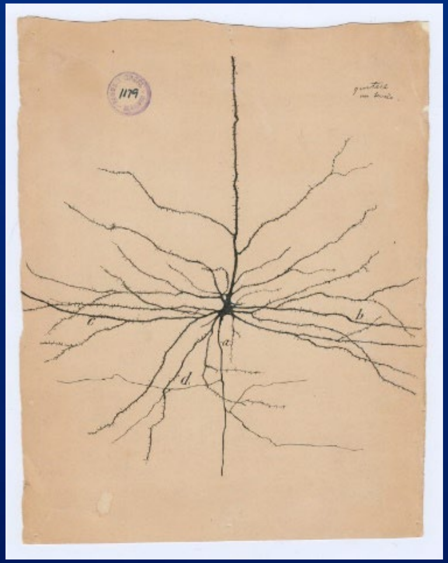
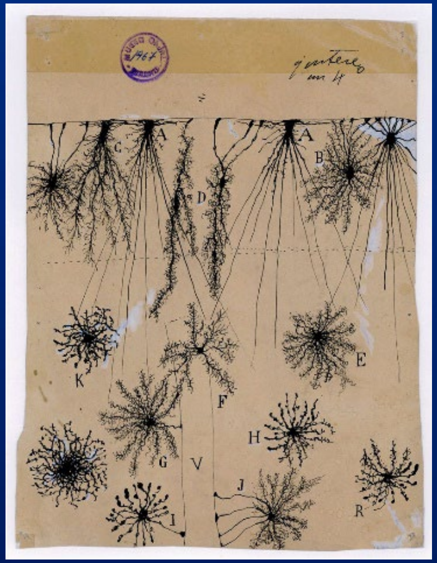
5R01DK129315-03

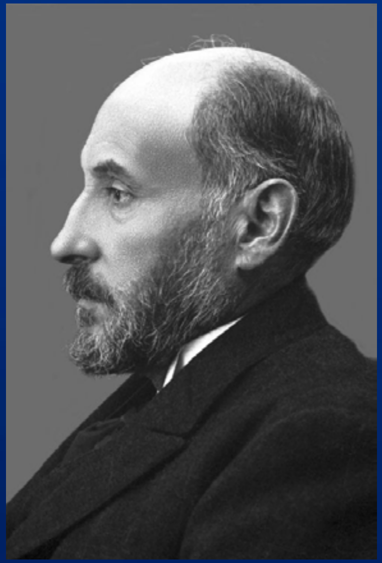


David R. Linden

2024 NIH ODSS AI Supplement Program Virtual PI Meeting, March 28, 2024

Structure-Function in Neuroscience



Images Courtesy of the Cajal Institute, Spanish National Research Council and the Nobel Prize Museum, Stockholm

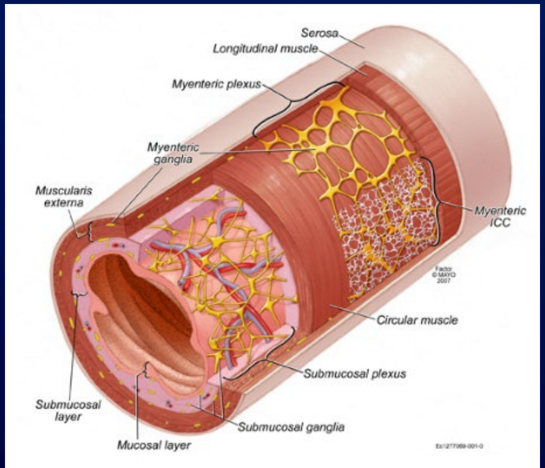
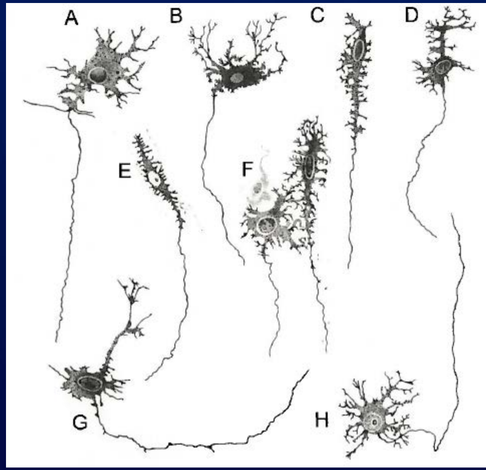
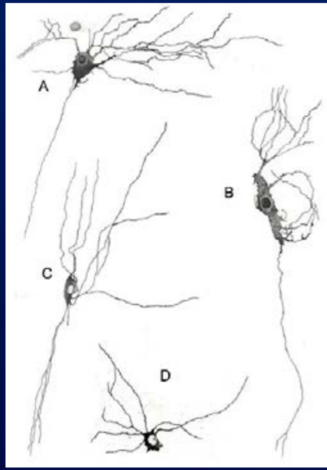
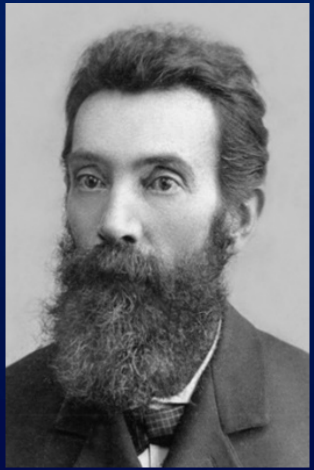
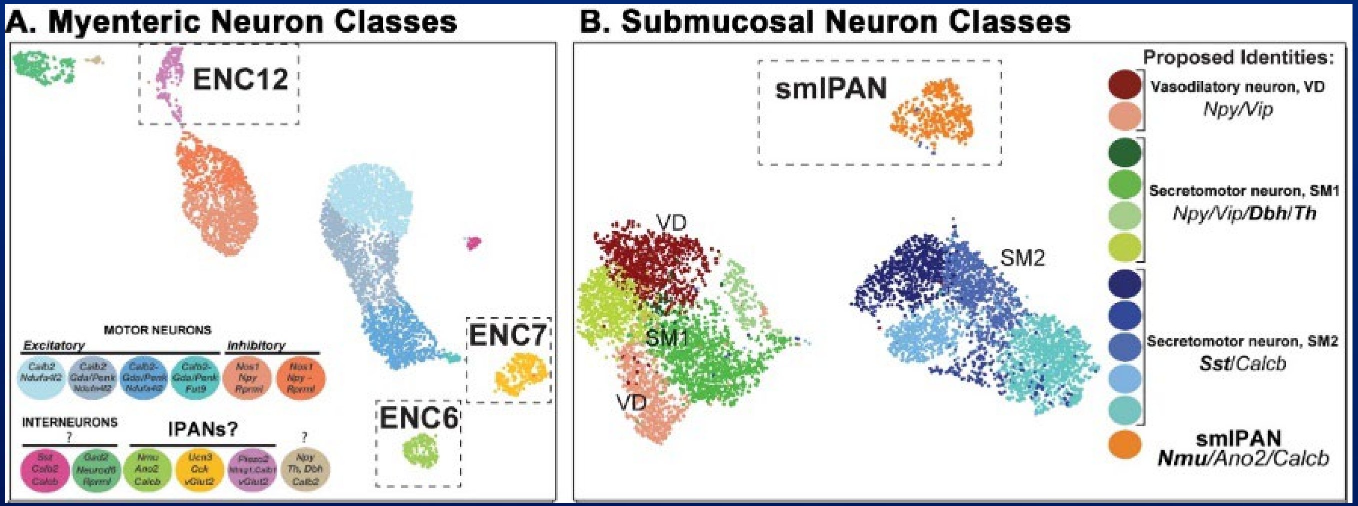


Figure From: Linden and Farrugia In: *Disorders of the Autonomic Nervous System 3rd Ed.*

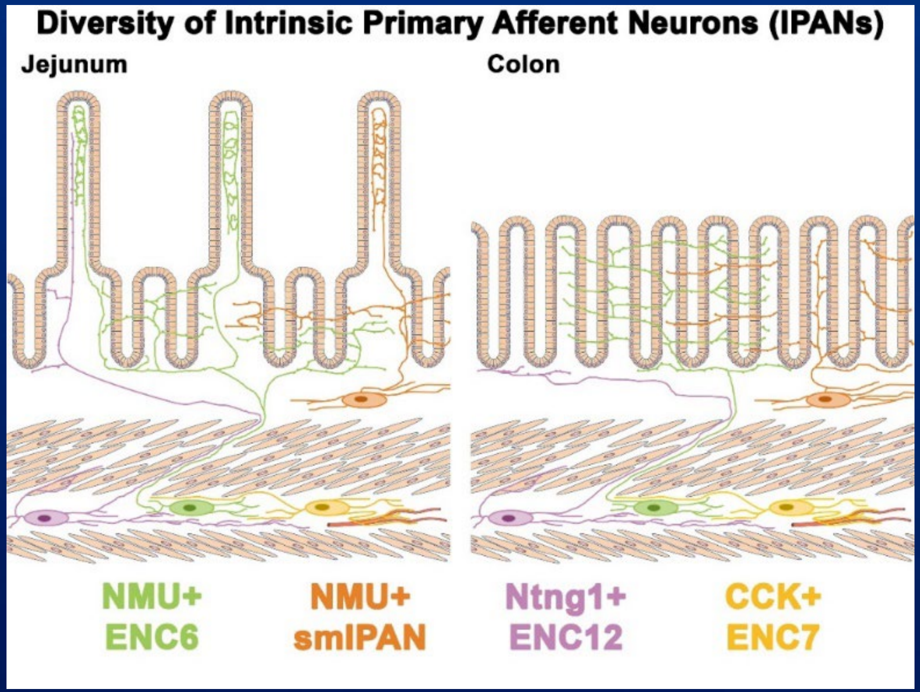




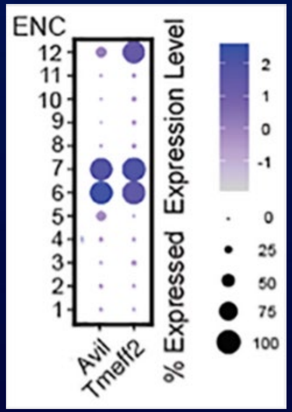
Images from Dogiel, 1899 Republished in Furness, 2004, *The Enteric Nervous System* and Courtesy of Tomsk State University

Single Cell Enteric Neuron Analysis



Morarach et al., 2021 *Nat. Neurosci.* **24**:34-46
Melo et al., 2020 *Neurogastroenterol Motil* **32**:e13989





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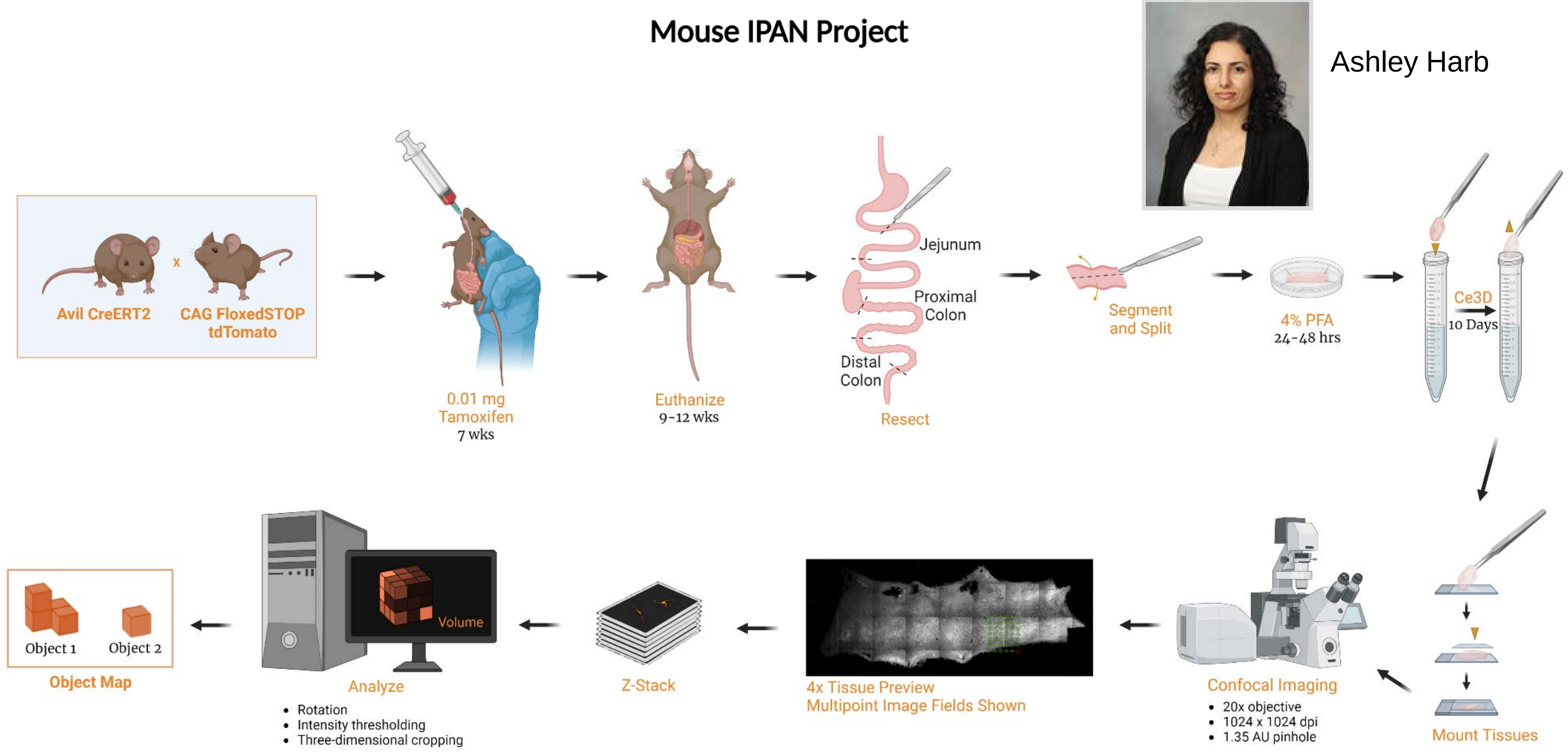
Ulrika Marklund

Different classes of IPANs possess morphologies and physiology that uniquely contribute to intestinal function

Model and Methods



Ashley Harb

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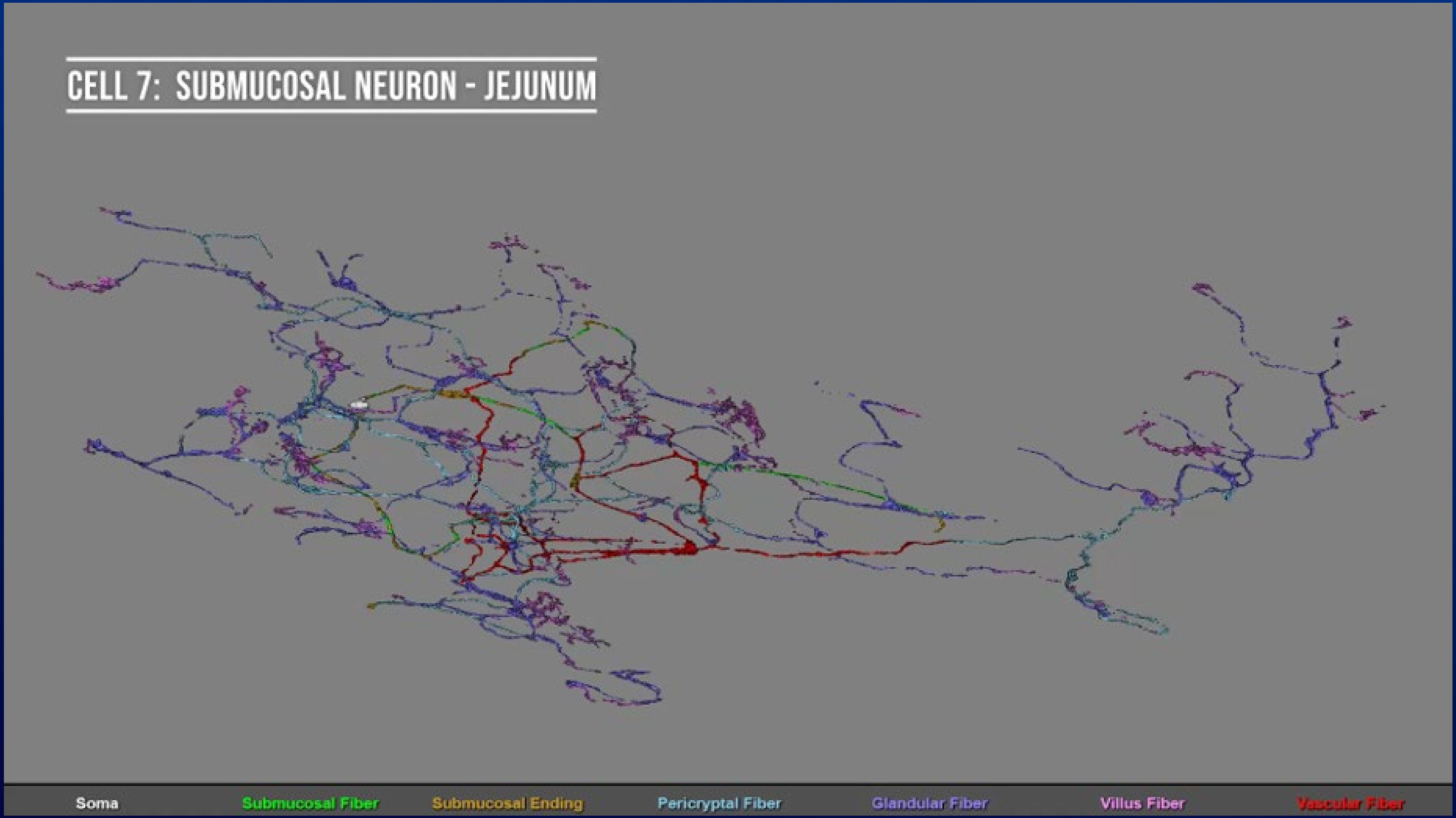
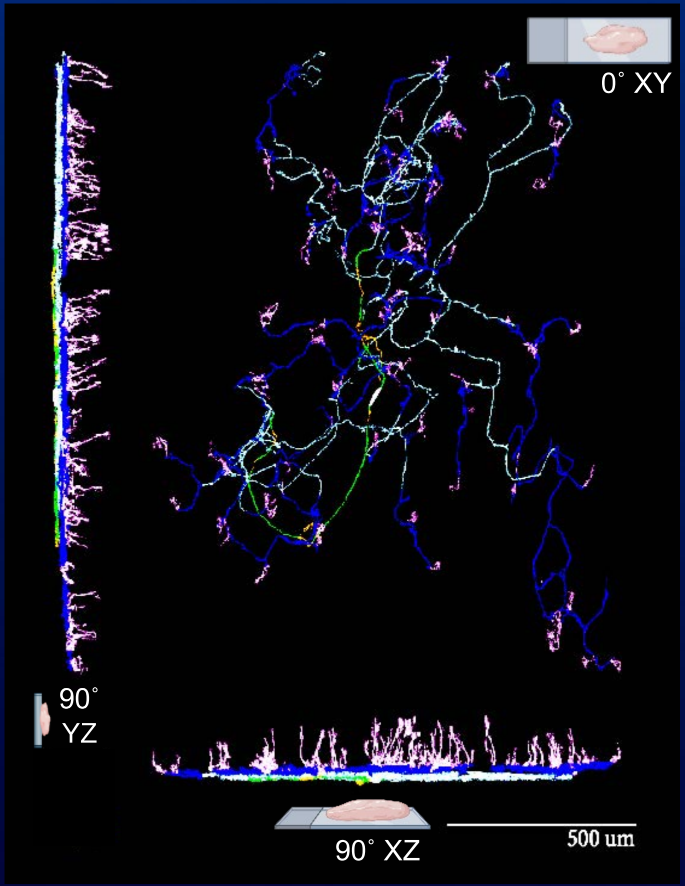
Single Cell 3D Reconstruction

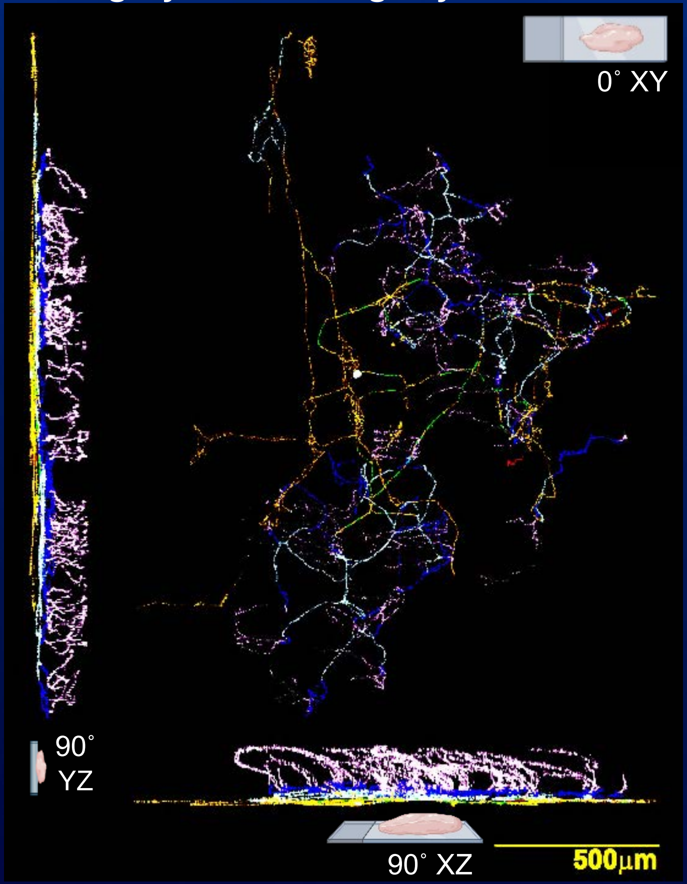


Three Cell Morphologies Based on Soma Location and Branching Pattern

1 Submucosal Cells



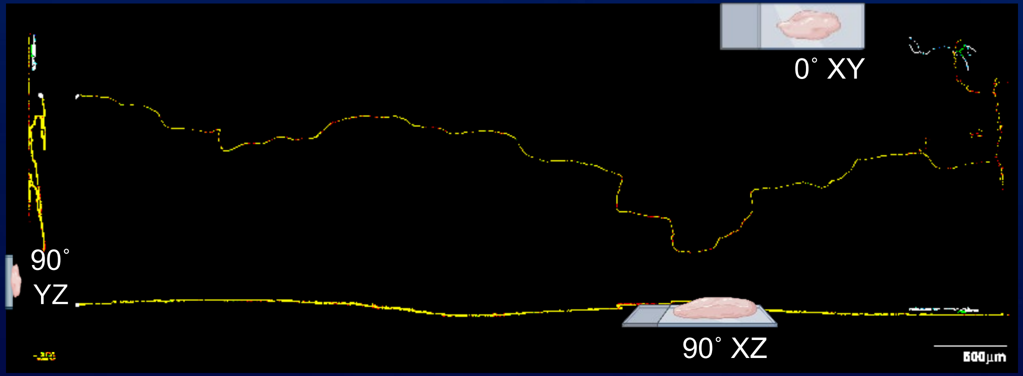
2 Highly-Branching Myenteric Cells



Myenteric Cells

Ashley Harb

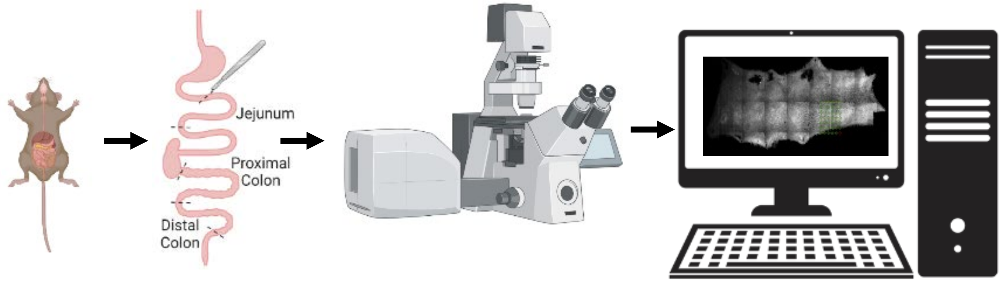
3 Long Descending Dogiel Type I Myenteric Cells



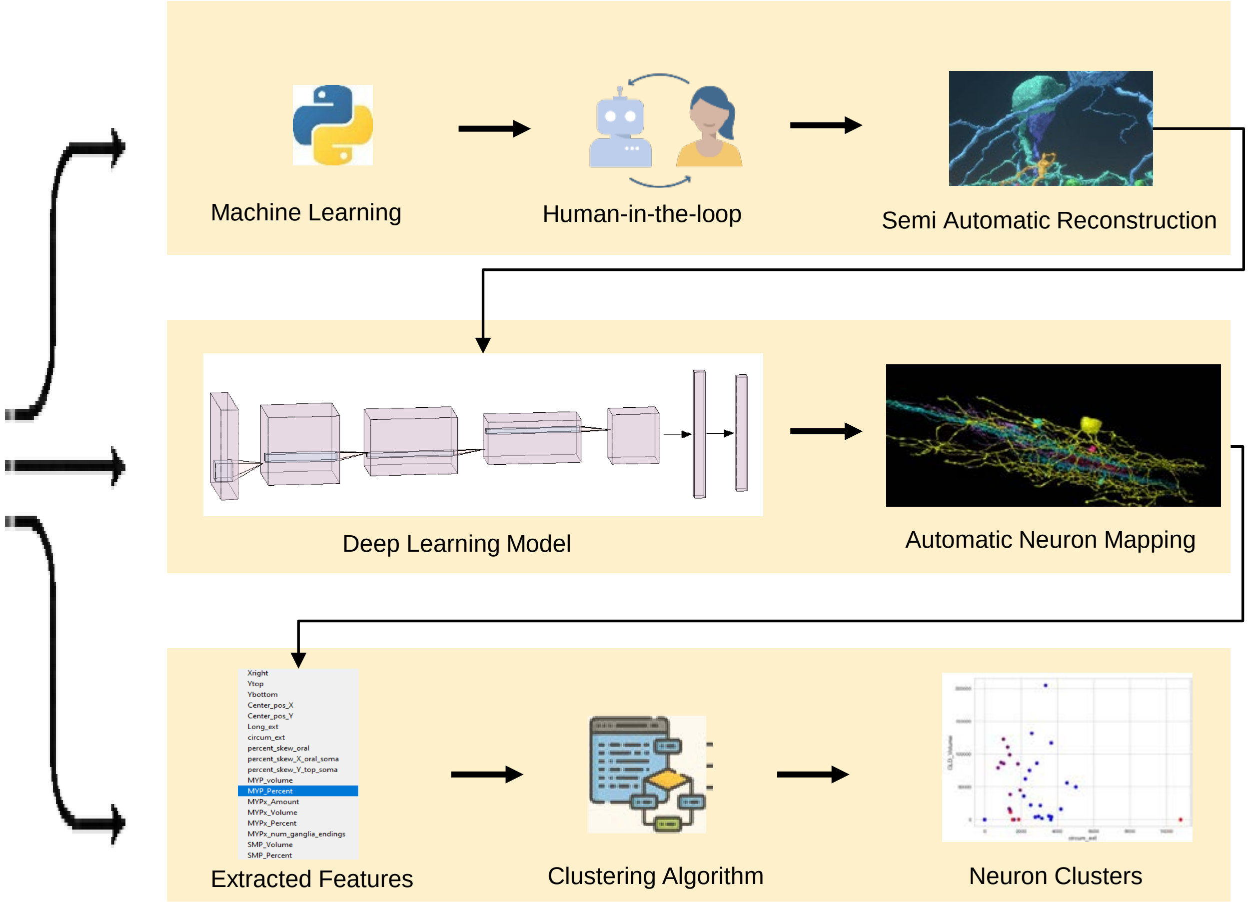
AI/ML Collaboration

Shivaram Poigai Arunachalam

Kamrul Foysal



Data Acquisition



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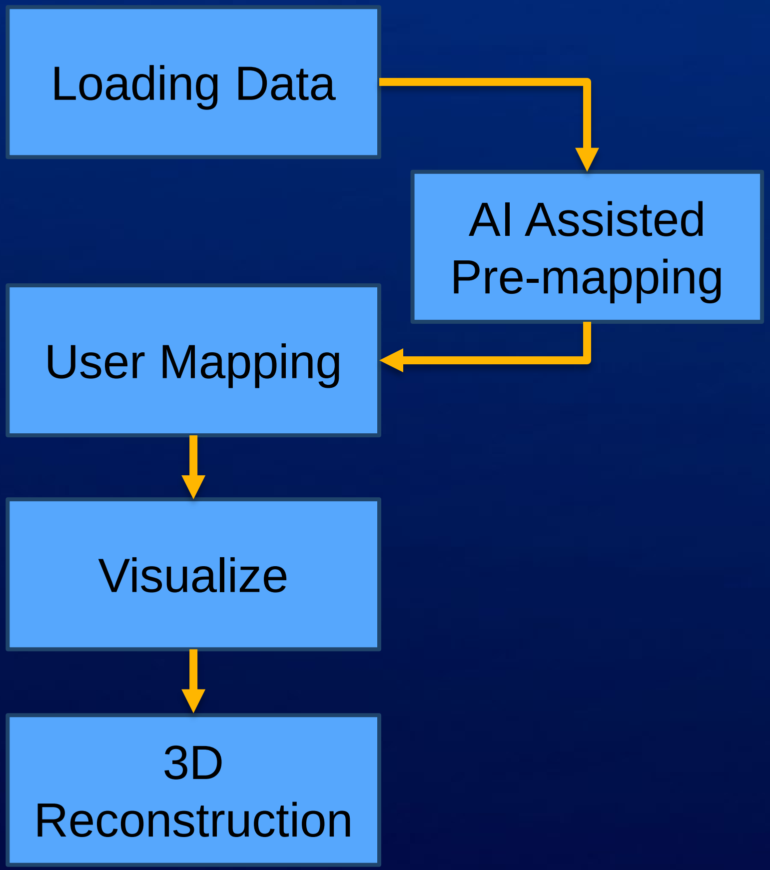
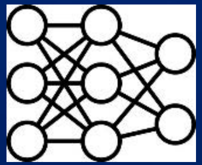
Semi-Automated Human-in-the-Loop AI Assisted Mapping

Image Processing

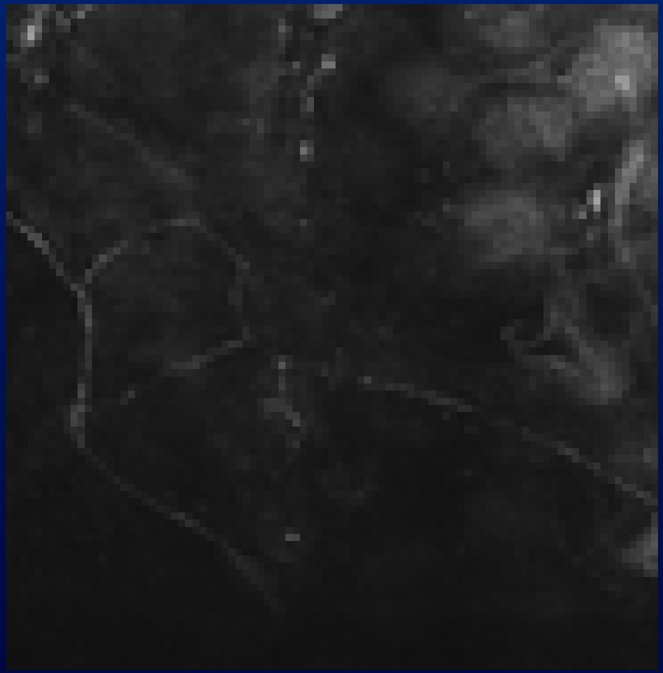


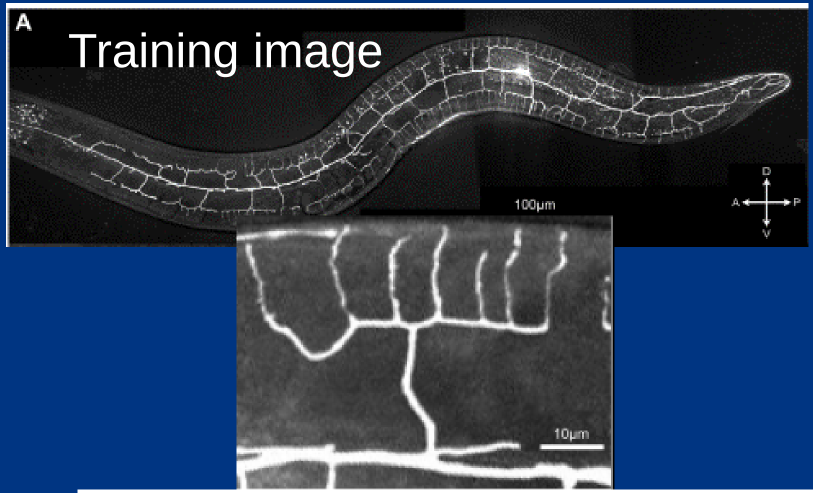


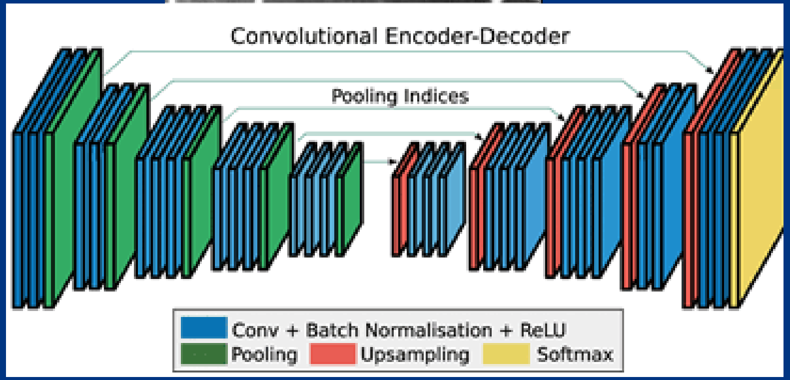
Machine Learning

AI Assisted Pre-Mapping

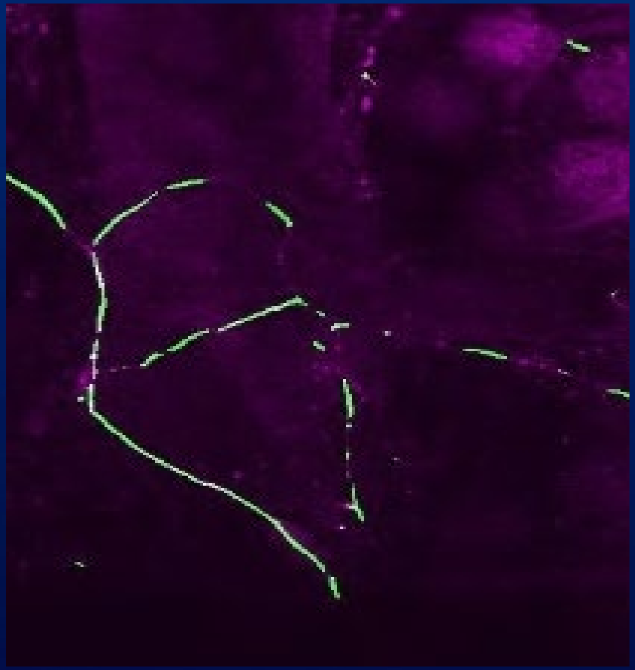
- Dataset Trained on *C. elegans* neuron
- Connect 3D Shapes, Cleans Data
- Suppress Background





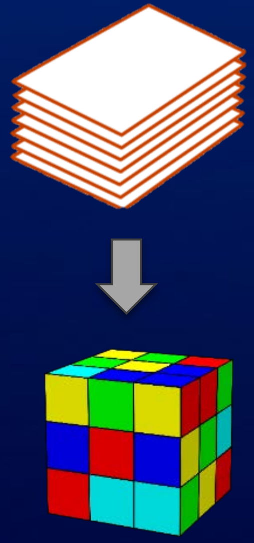


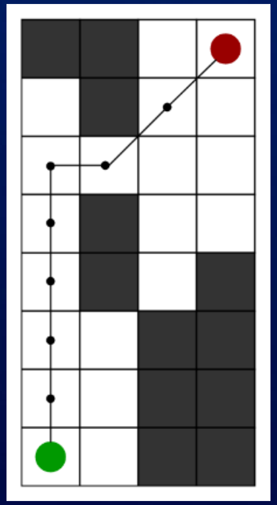
CNN Model

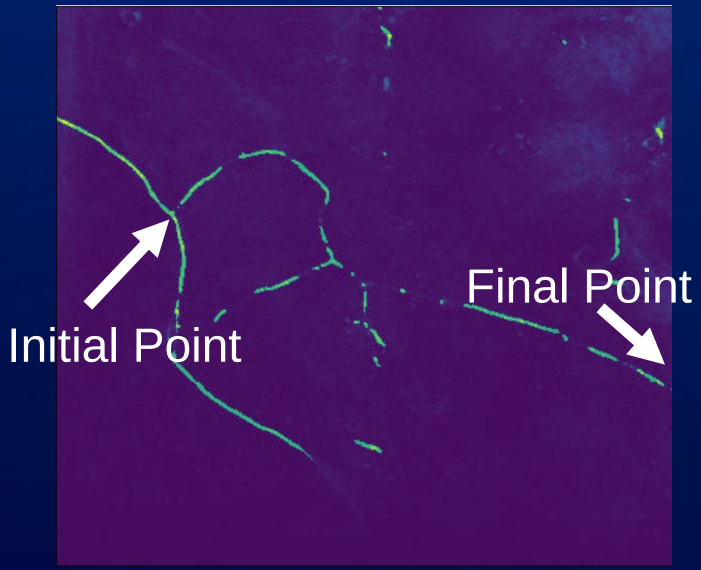


User Mapping Function

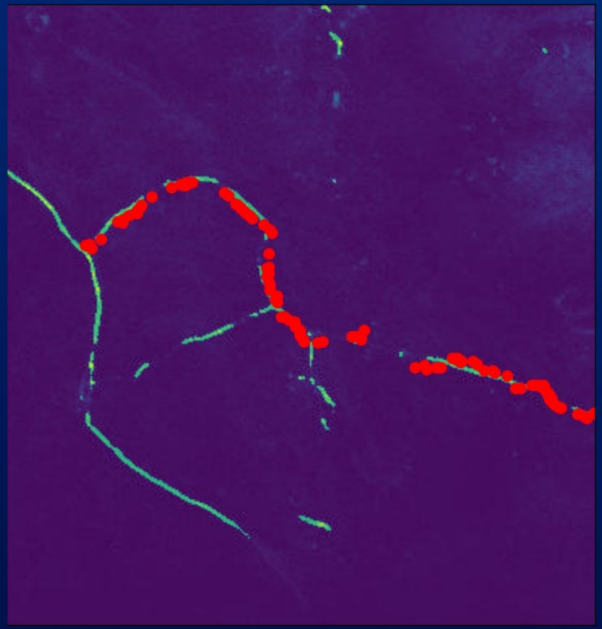
- 3D Graph Search
  - Dijkstra’s Algorithm
  - A Star Search Algorithm



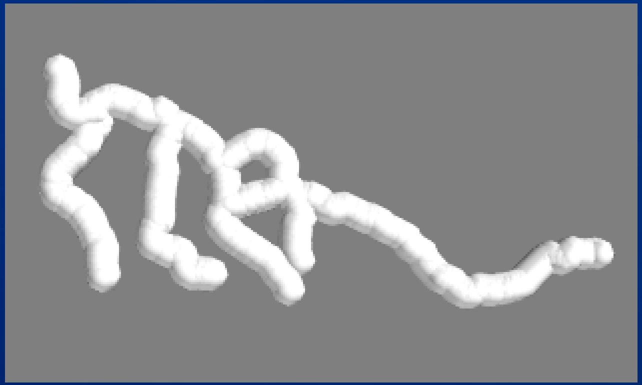




- Broken paths can be connected.
- User defines the Start and the End of the Neurite Branch.
- The mapping is performed in 3D.

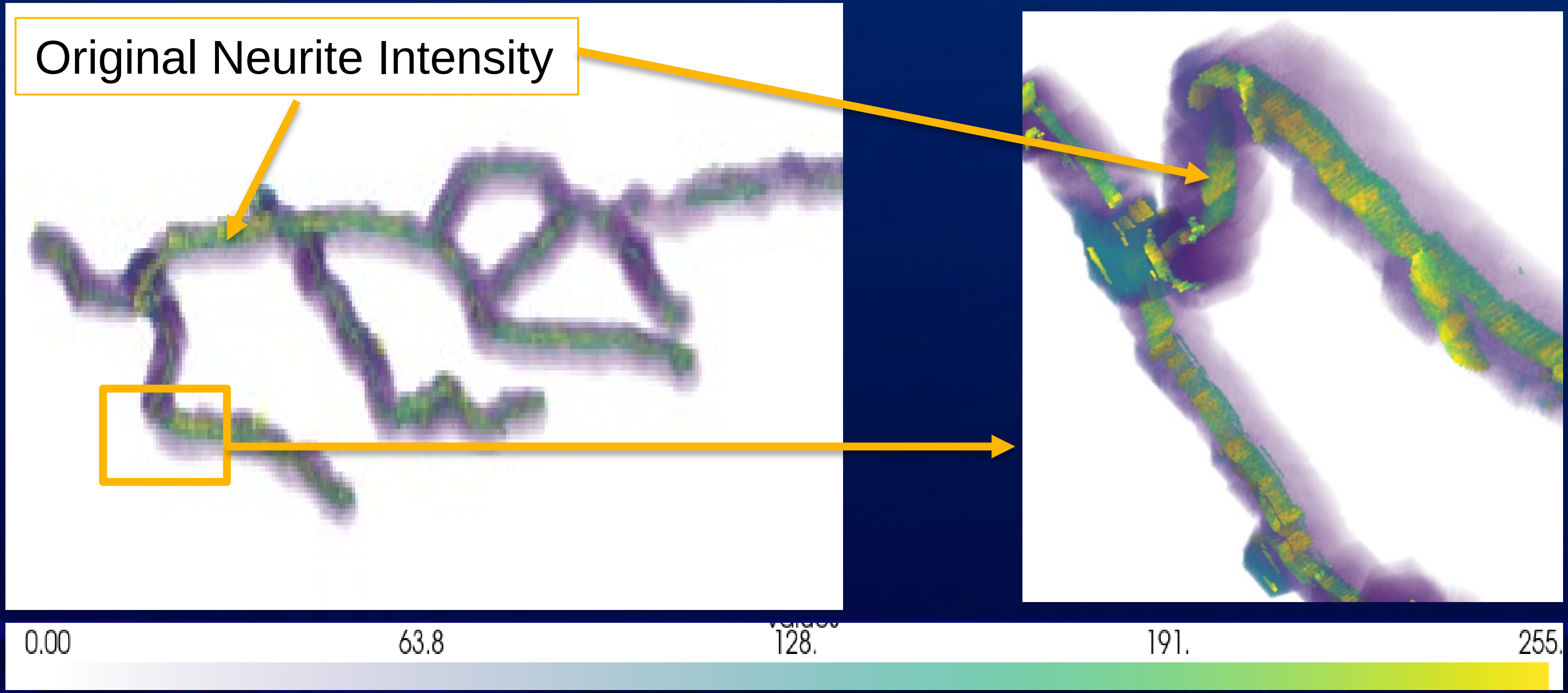


Mapping Function: Neurite Extraction



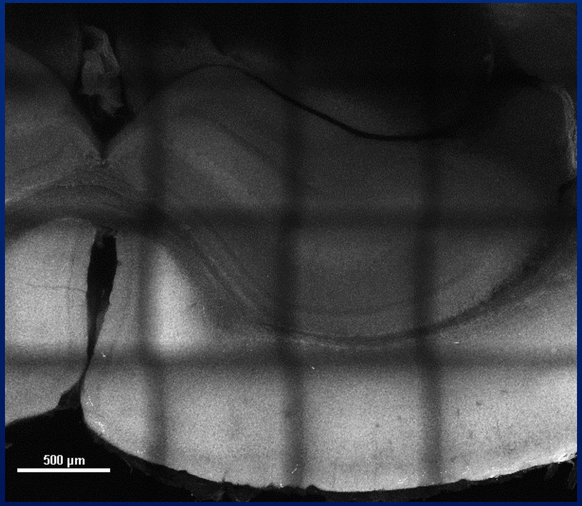
3D Volumetric Mask

- Traced 3D Voxels act as 3D Volumetric Mask
- Intensity Variation is captured within mask
- Adaptive histogram equalization extracts the neuron structure
- The whole neuron is one single connected object

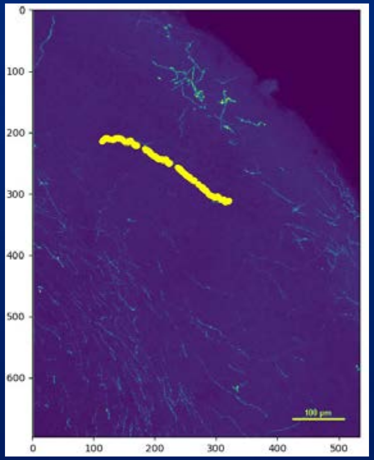


Neurite Strand

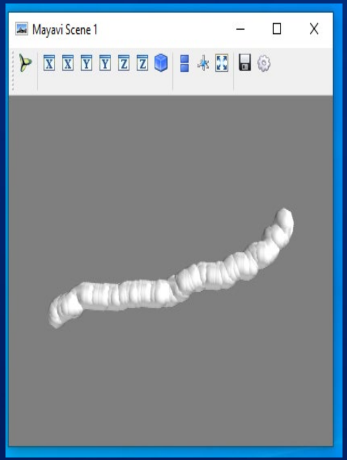
Application to Broad Neuroscience Field

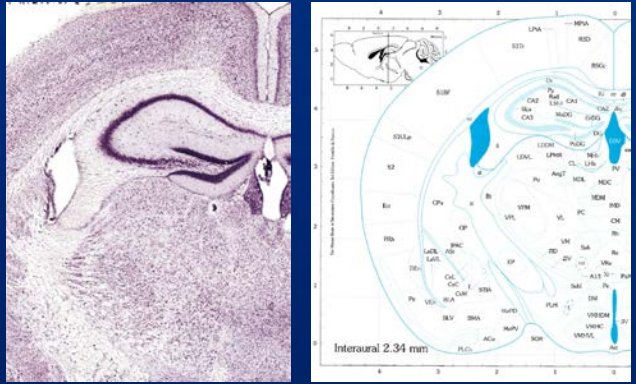


Mapped Neuron



Neuron Mask in 3D





Franklin and Paxinos *The Mouse Brain In Stereotaxic Coordinates 3rd Ed.* 2008.

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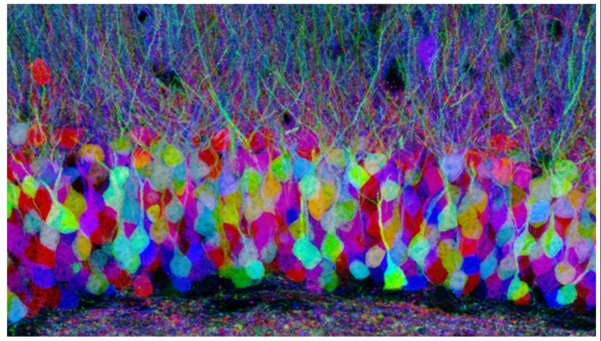



Chuck Howe


Ben Clarkson

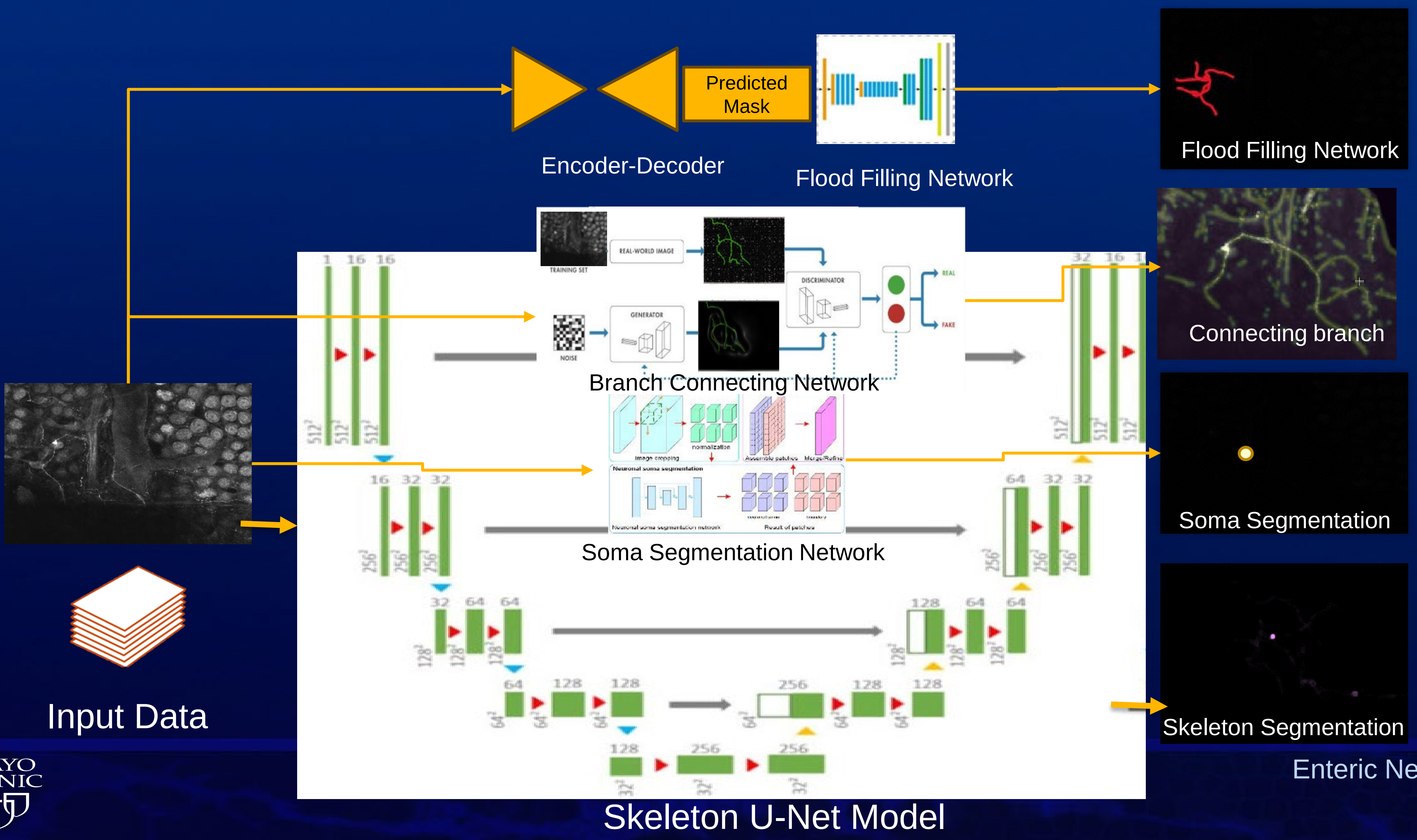

Maria Westphal


Kamrul Foysal


Tim Kline


George Cao

Hybrid Automated Enteric Neuron Mapping Model

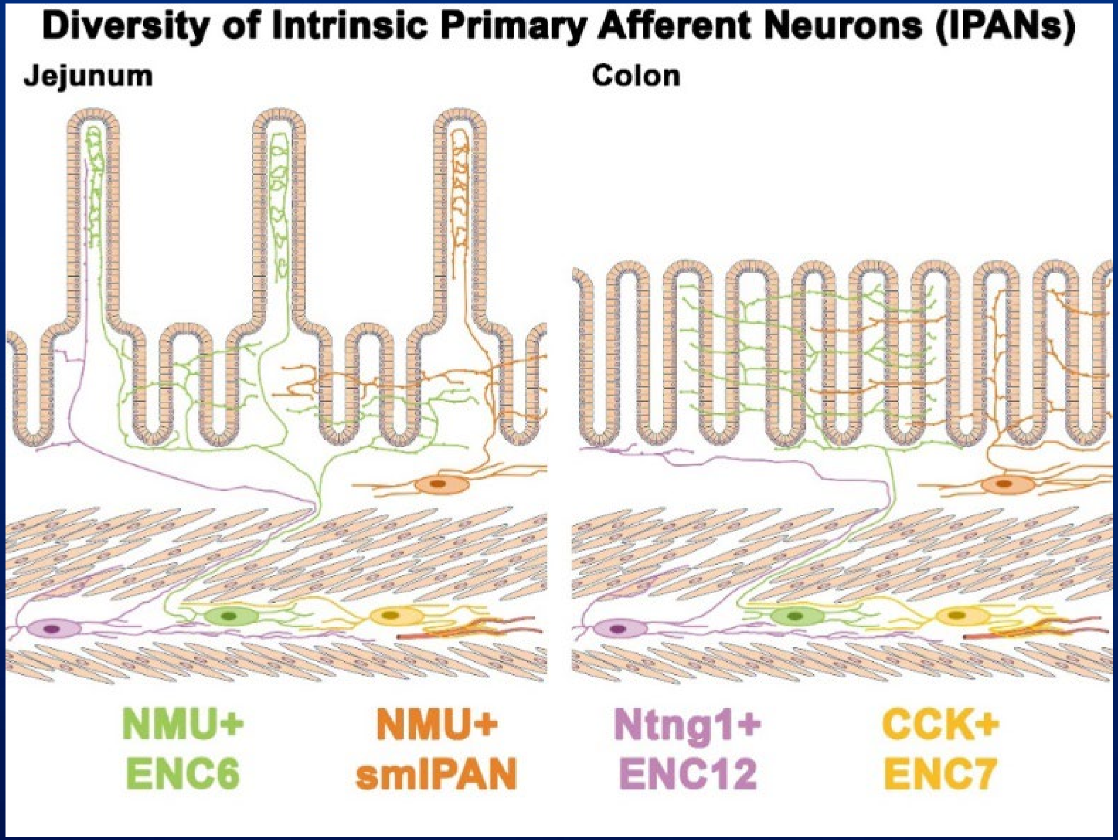


Kamrul Foysal

Output Mask

Conclusions

- AI / ML Supports Aims of Parent R01
  - Enhanced Throughput
  - Enhanced Objectivity
- Creation of Neuron Morphology Datasets for Future AI / ML
  - Ground Truth to Improve Fully Automated AI/ML Models
  - Applicability to Broad Neuroscience Community



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