

# CAREER: Physical Principles and Applications of Plant-Inspired Tip Growth for Robotics

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**engineering**

# Navigating the Environment

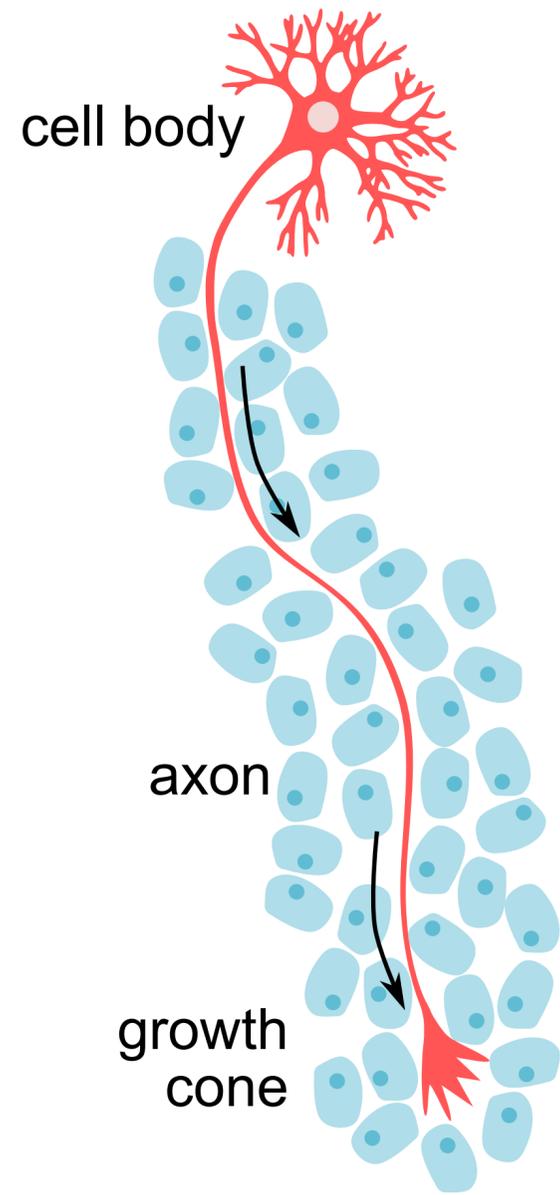
How do we reach the target?



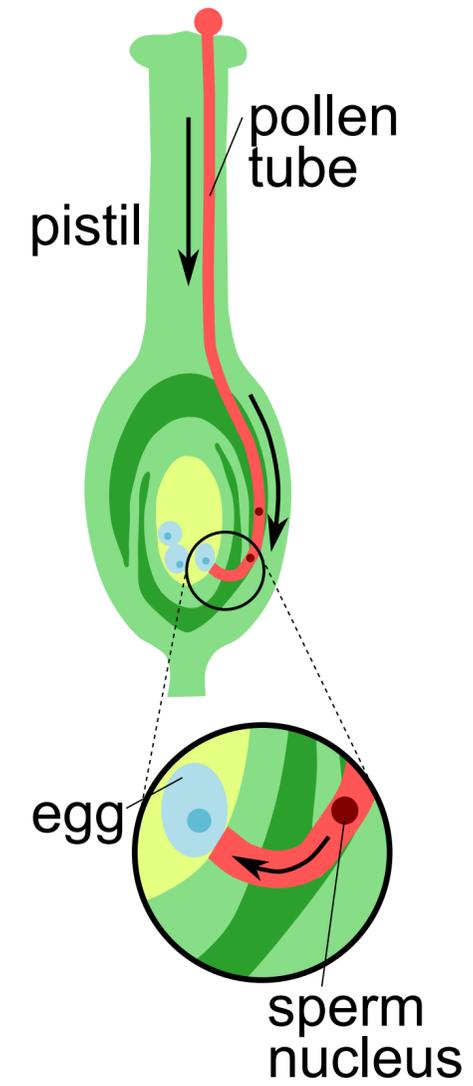
# Locomotion

Moving the entire body





neuron:  
**connection for signals**

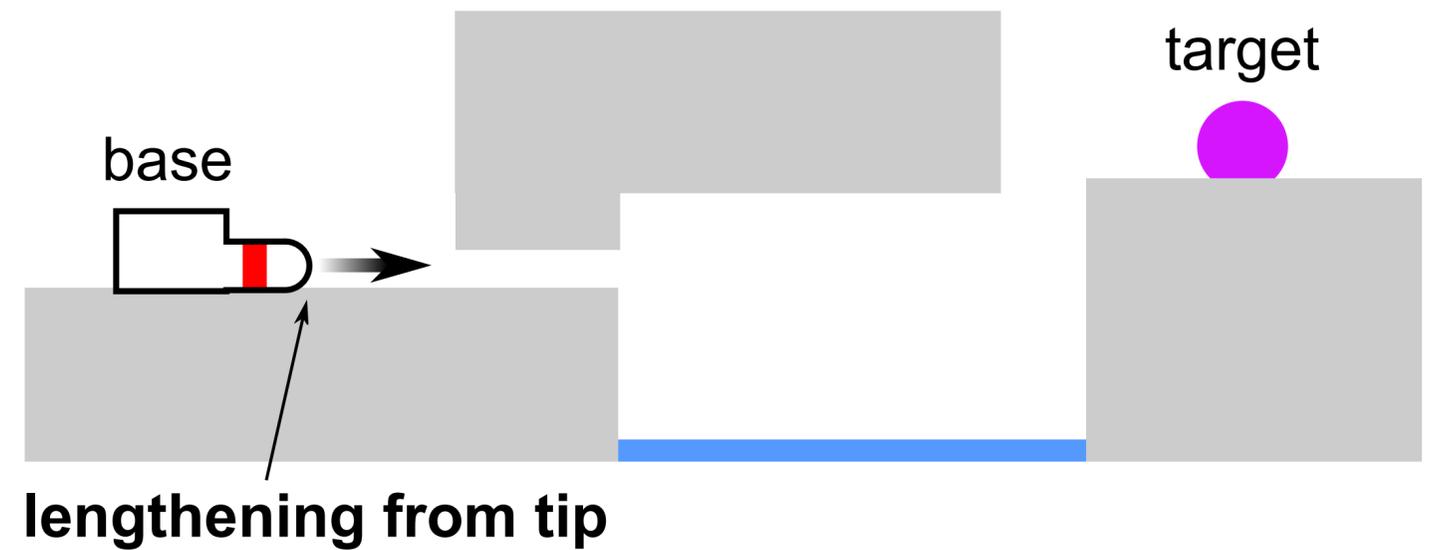


pollen tube:  
**conduit for delivery**

# Growth from Tip

New material is added at the tip

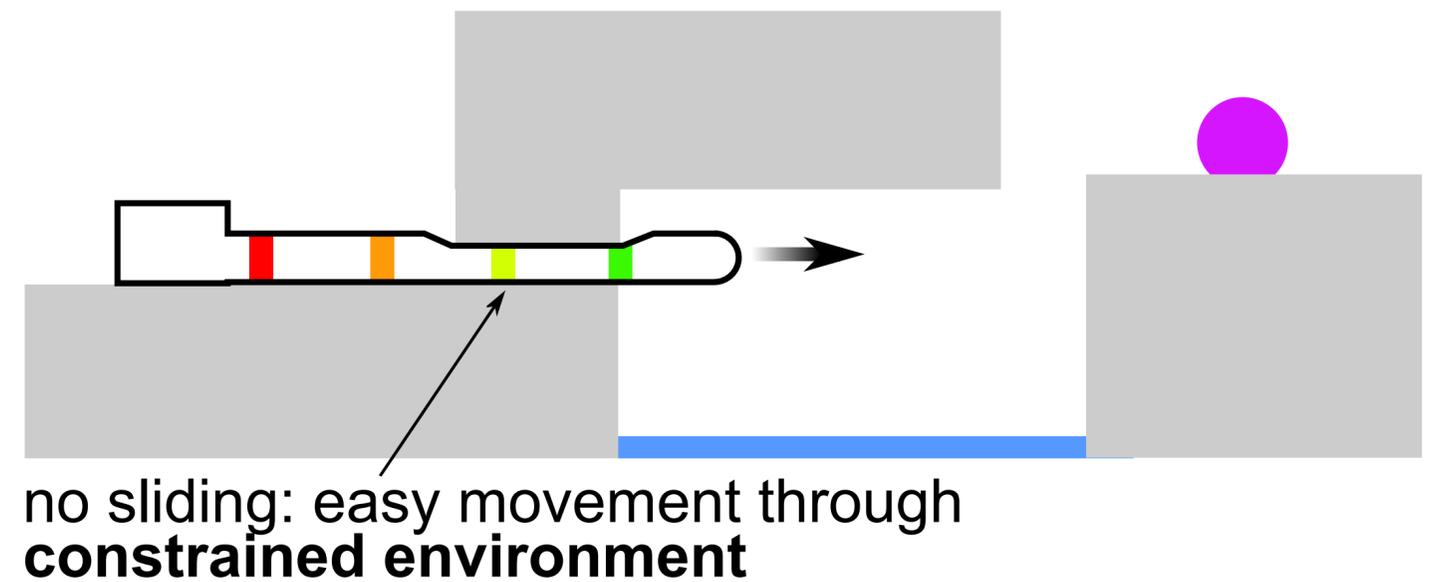
Entire body is stationary



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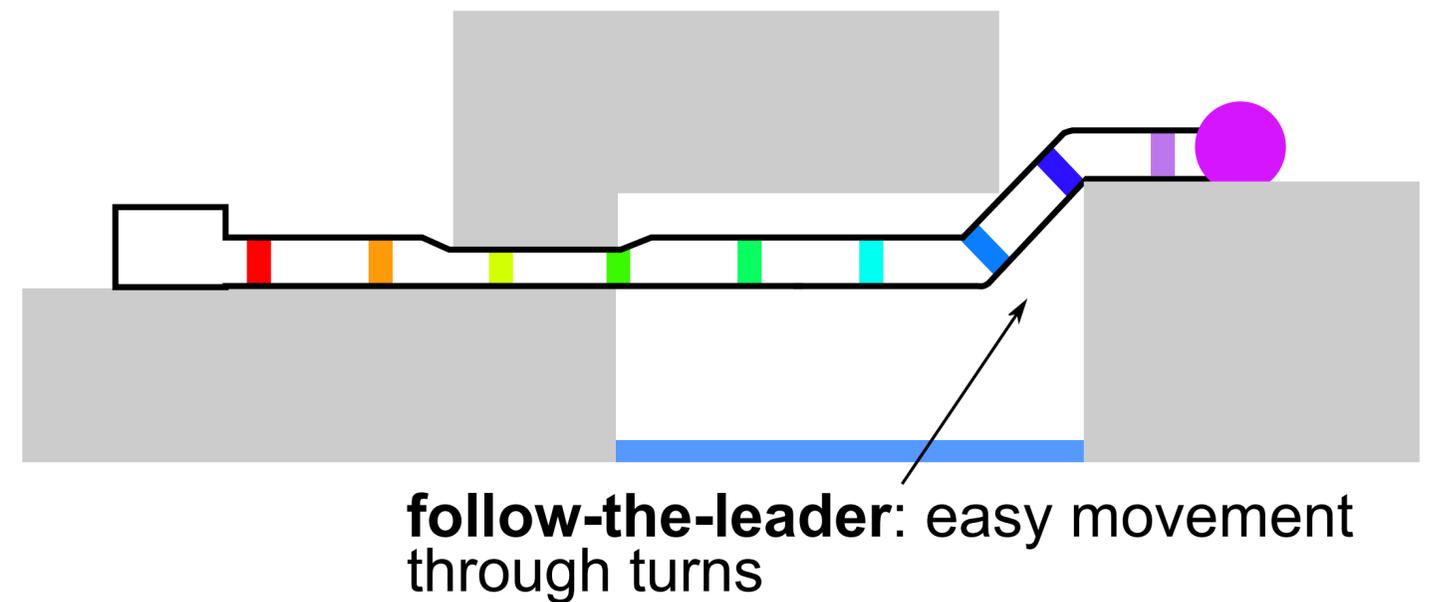
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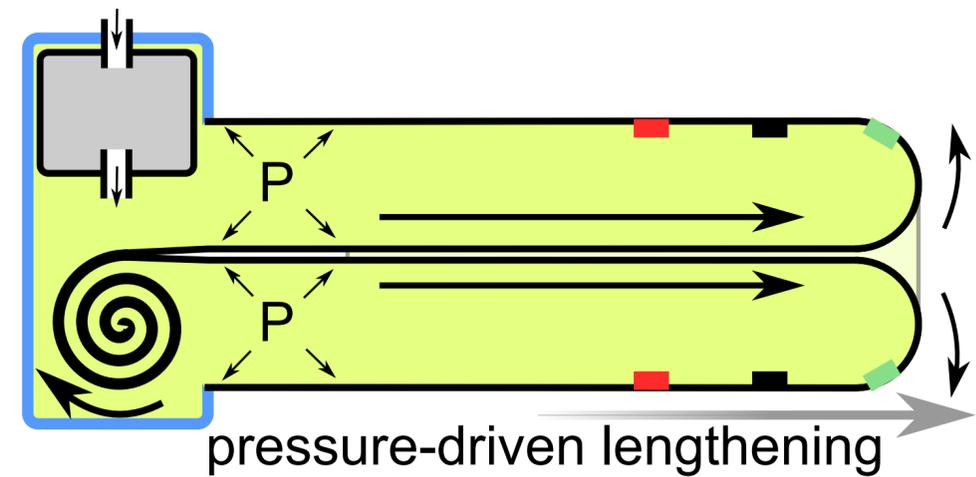
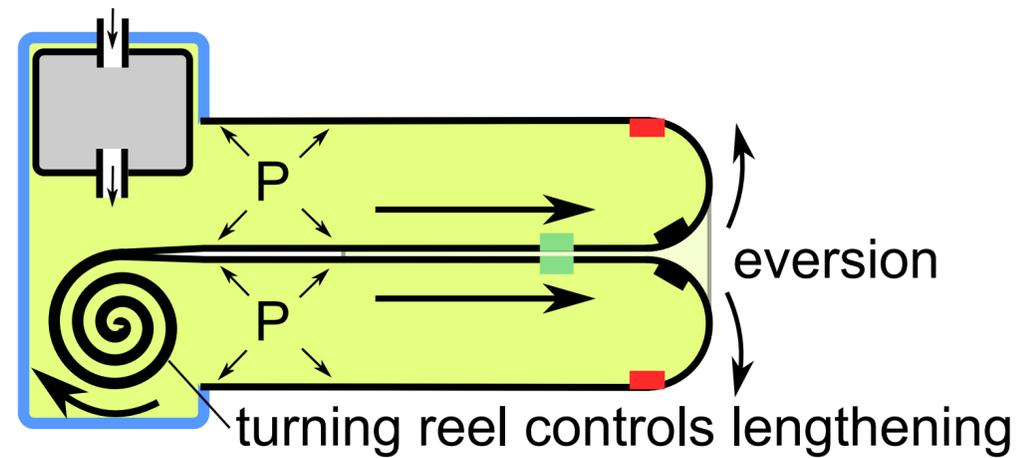
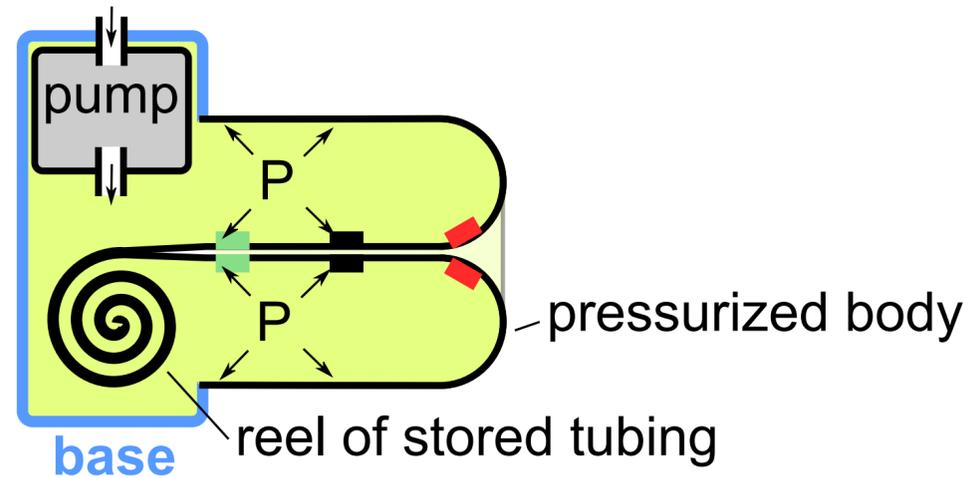
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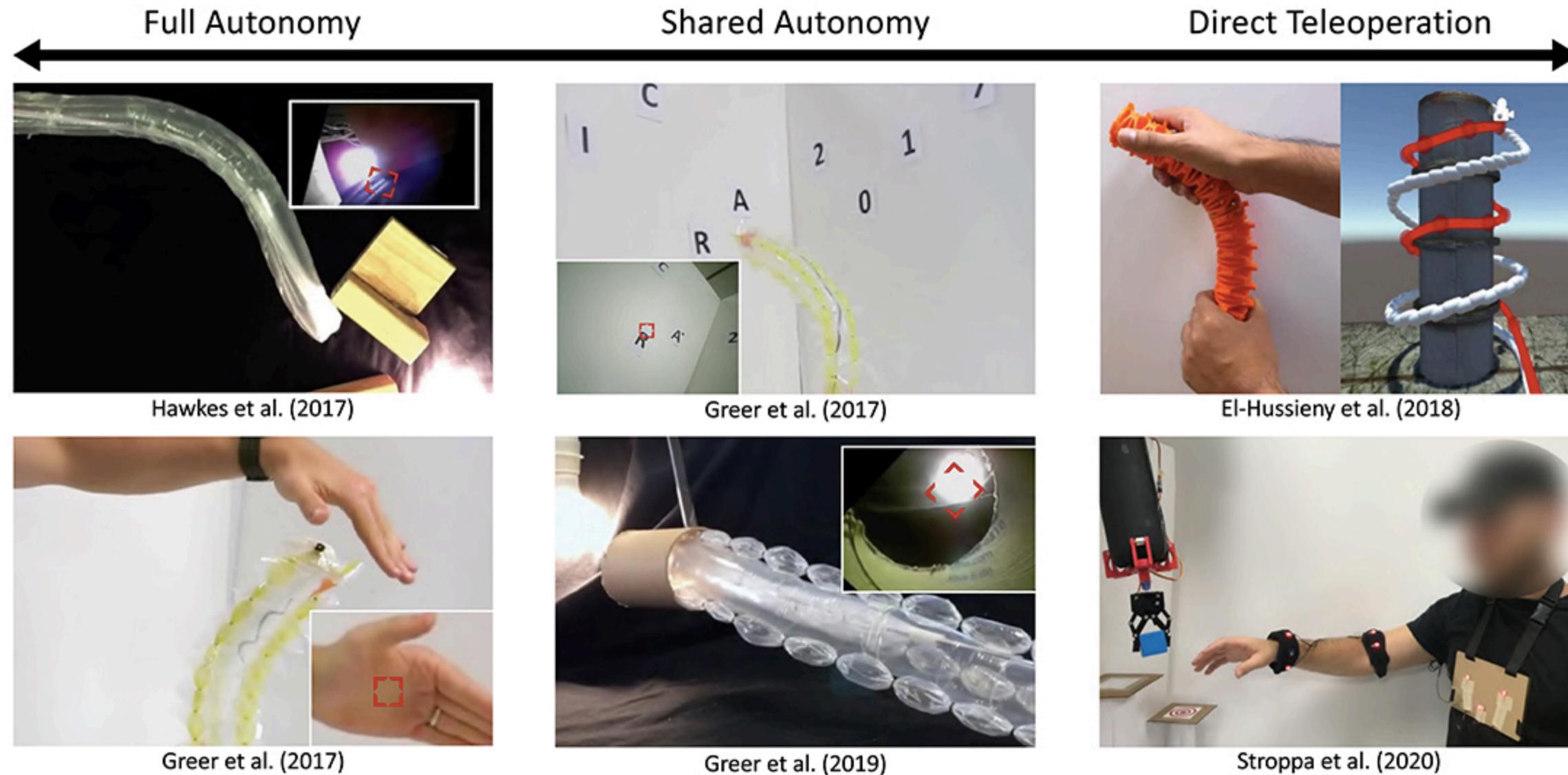
# Implementing Tip “Growth”



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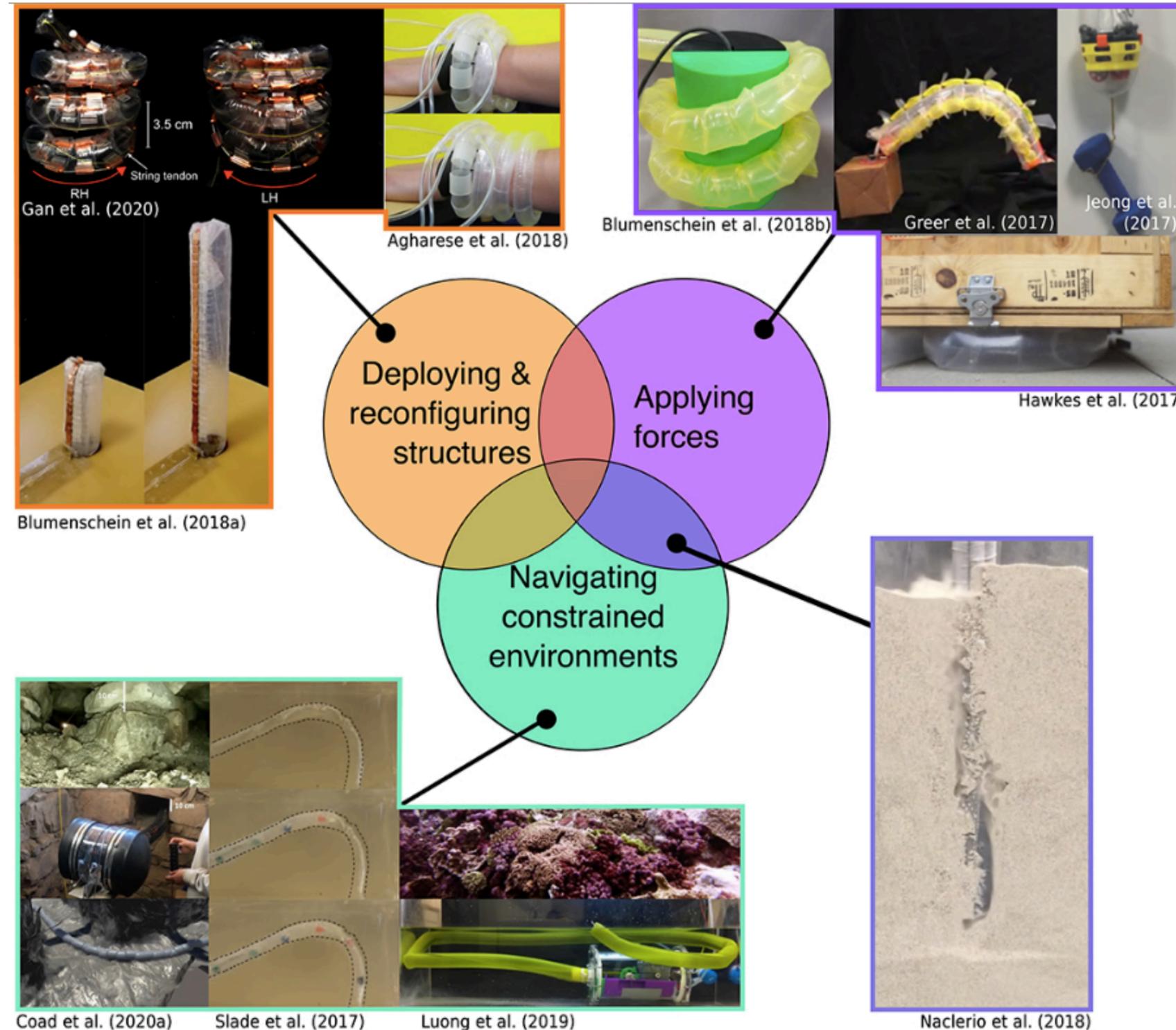


# 1) Design, Modeling, Control: Organizing Current Knowledge



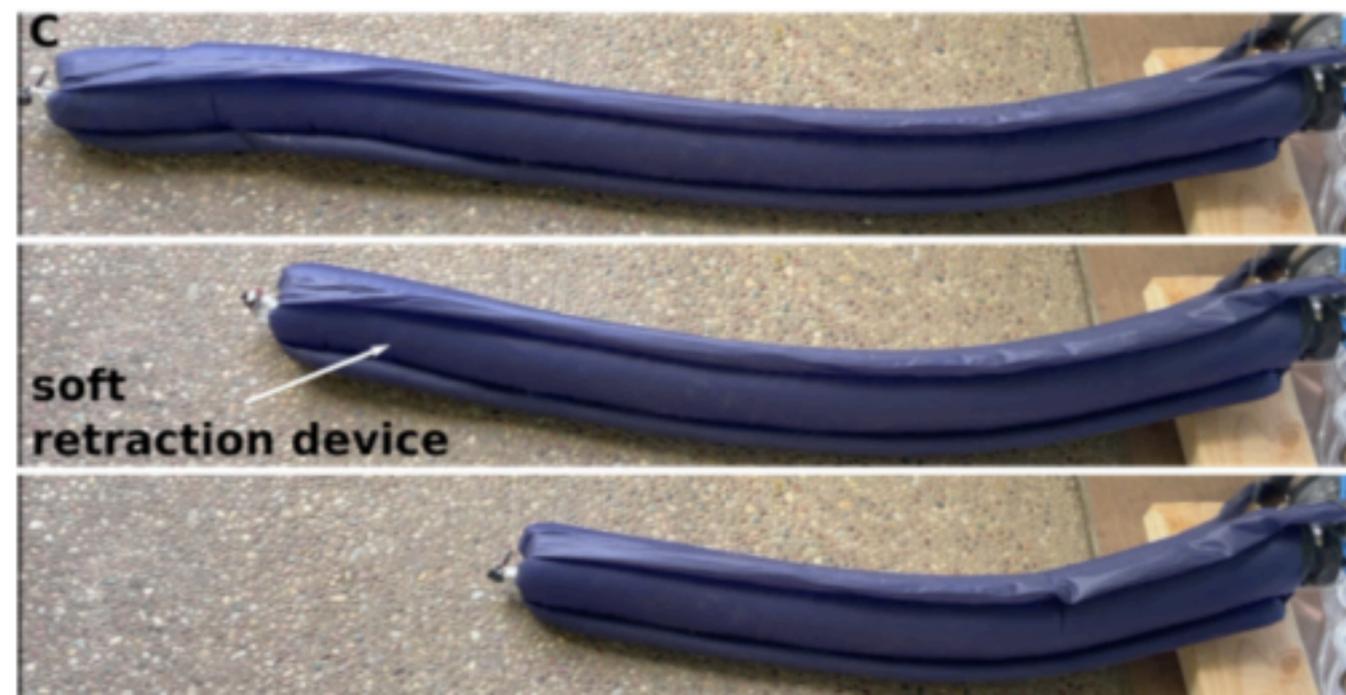
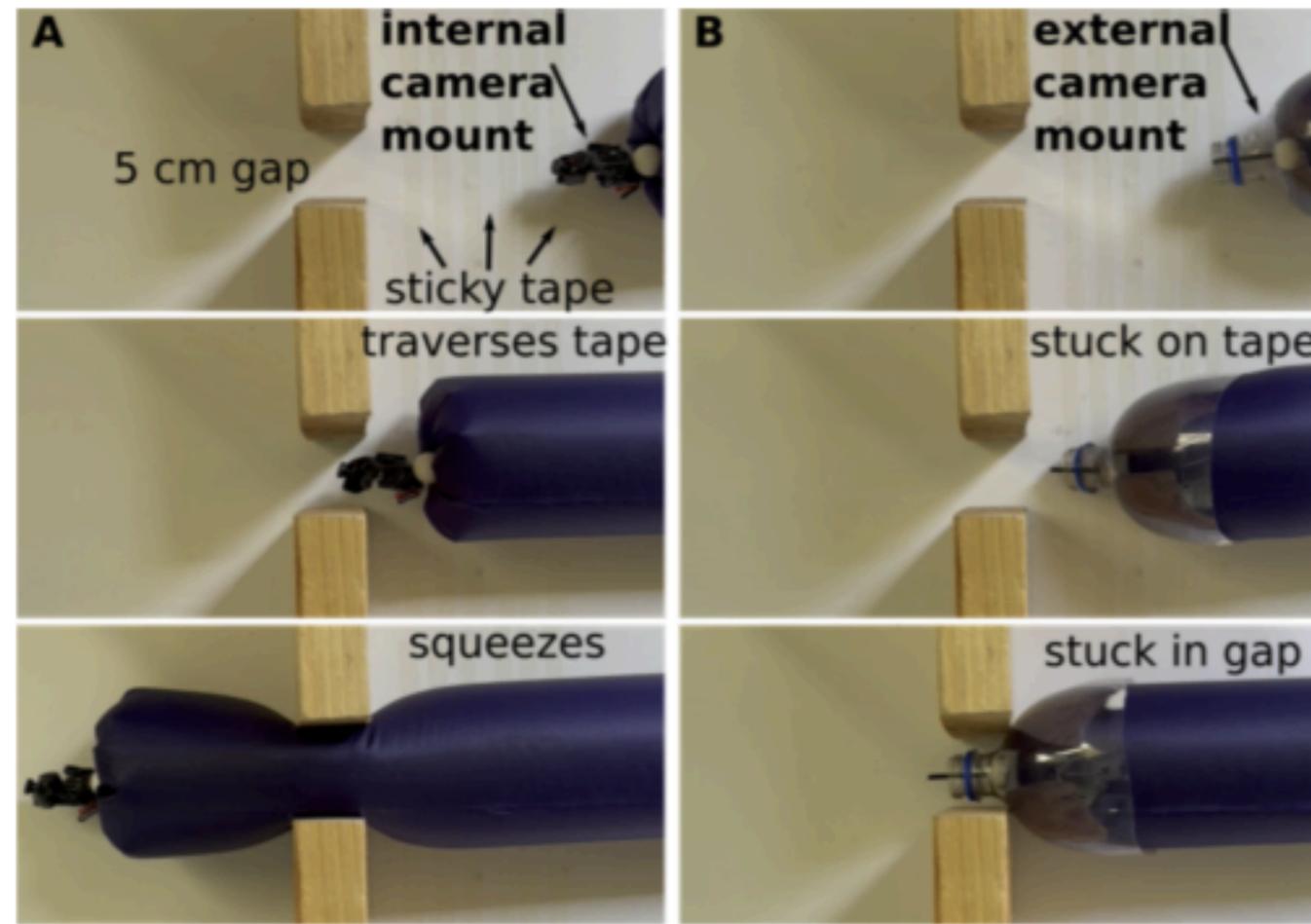
Blumenschein, Laura H. and  
Coad, Margaret M. and Haggerty,  
David A. and Okamura, Allison  
M. and Hawkes, Elliot W..  
(2020). Design, Modeling,  
Control, and Application of  
Everting Vine Robots. *Frontiers  
in Robotics and AI*. 7 .

# Design, Modeling, Control: Organizing Current Knowledge



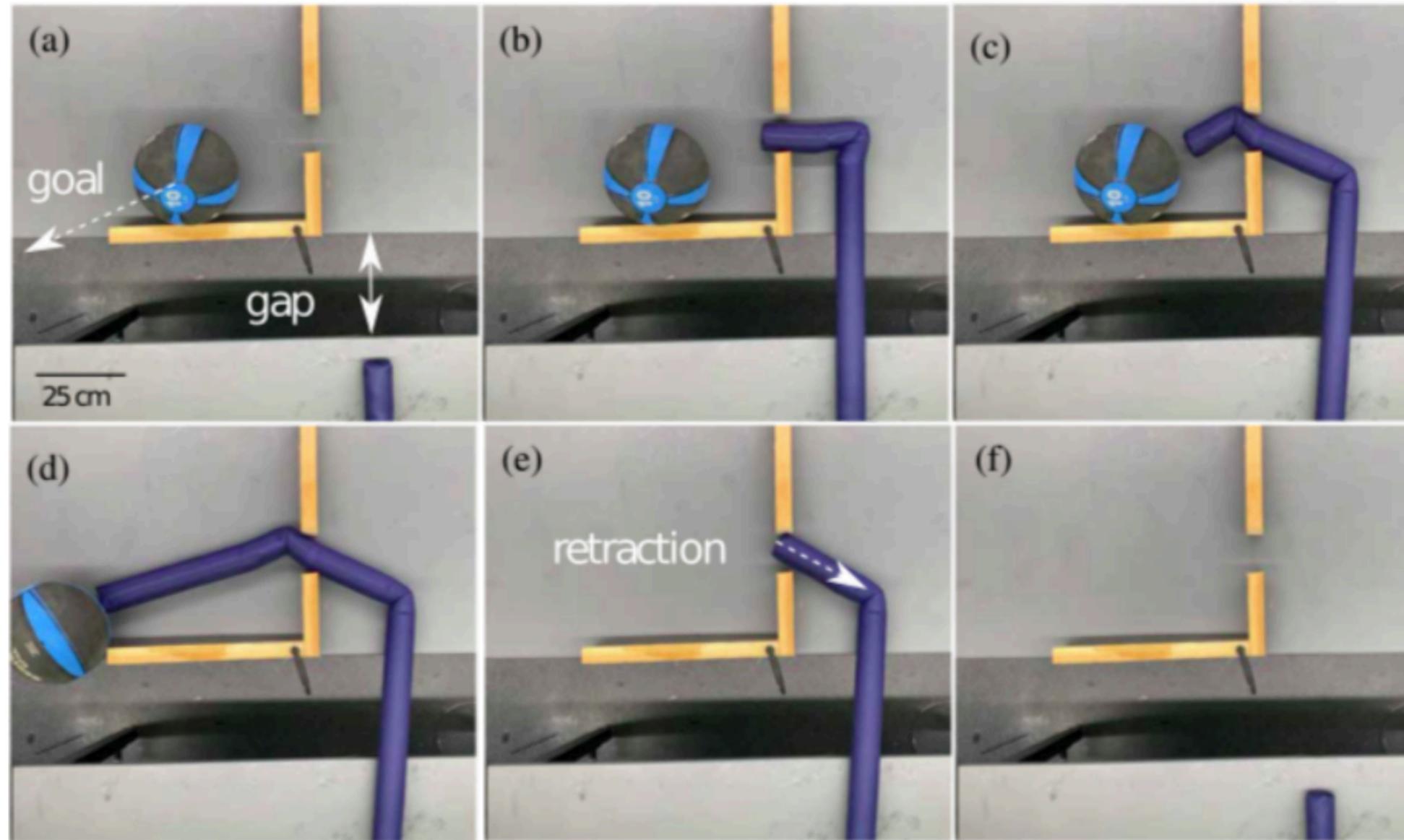
Blumenschein, Laura H. and Coad, Margaret M. and Haggerty, David A. and Okamura, Allison M. and Hawkes, Elliot W.. (2020). Design, Modeling, Control, and Application of Everting Vine Robots. *Frontiers in Robotics and AI*. 7 .

# Soft camera mount and retraction



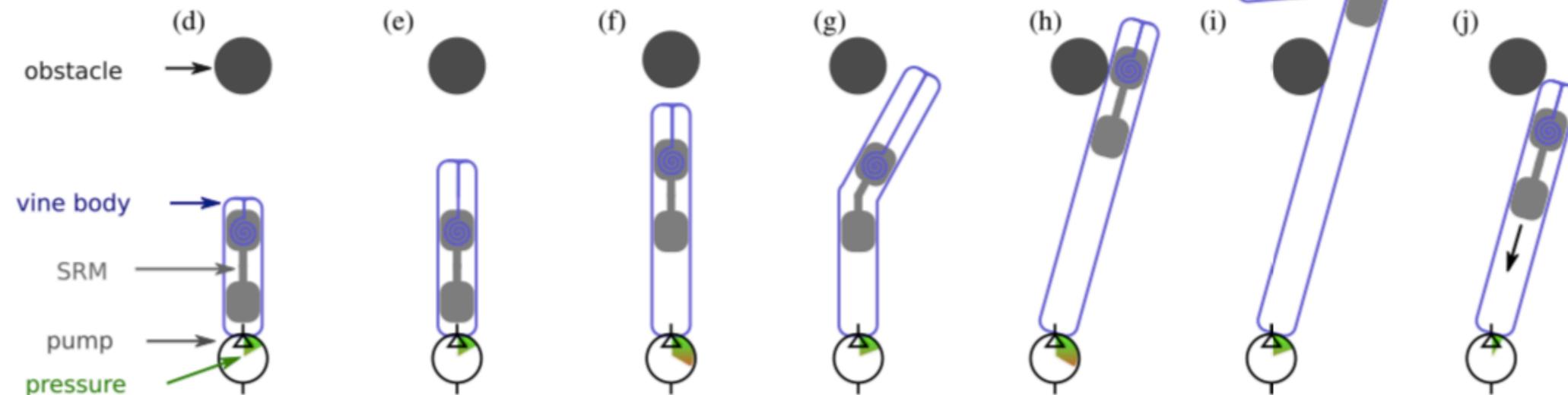
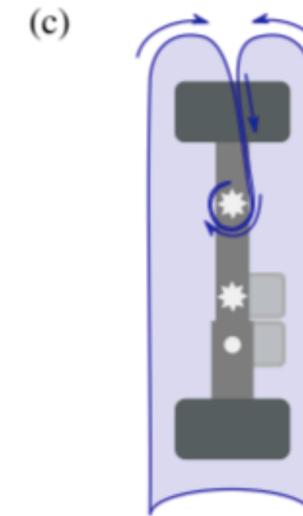
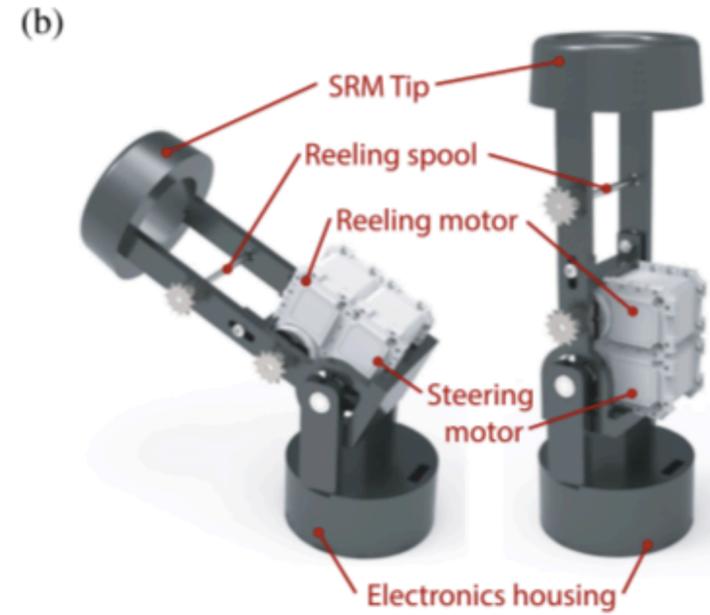
Heap, W.E., Naclerio, N.D.,  
Coad, M.M., Jeong, S.G. and  
Hawkes, E.W., 2021, January.  
Soft Retraction Device and  
Internal Camera Mount for  
Everting Vine Robots. In 2021  
IEEE/RSJ International  
Conference on Intelligent Robots  
and Systems (IROS) (pp.  
4982-4988). IEEE.

# New steering and retraction



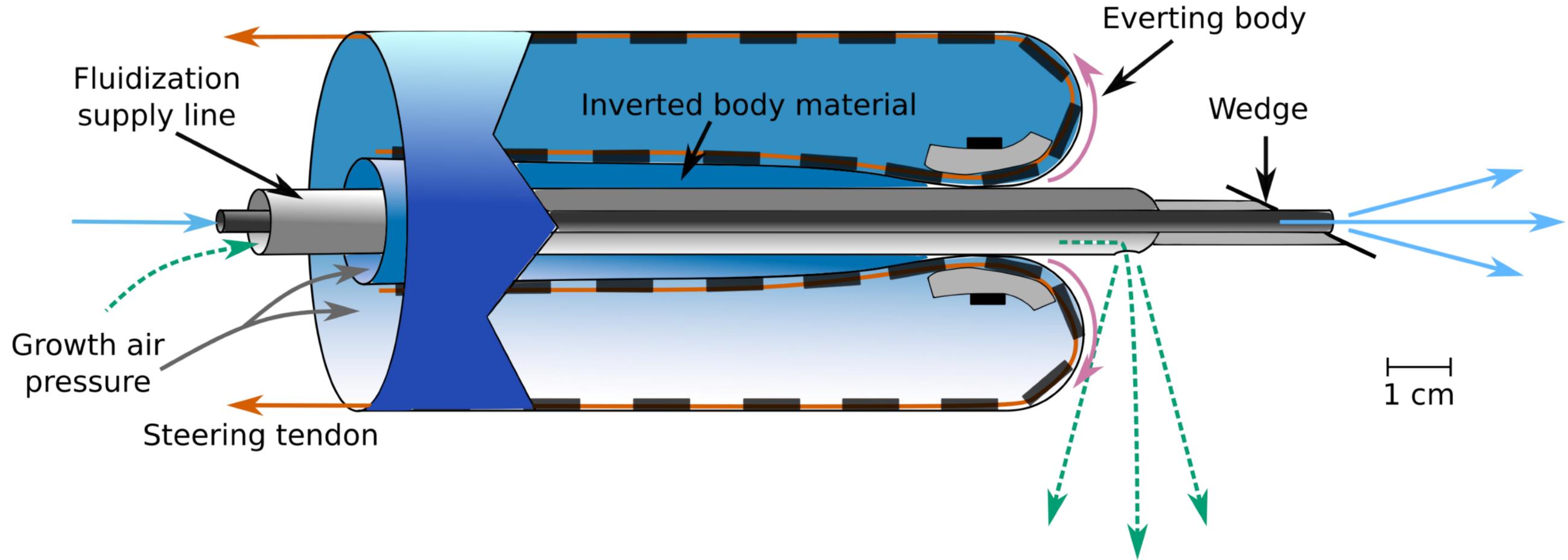
Haggerty, David Arthur and Naclerio, Nicholas and Hawkes, Elliot Wright. (2021). Hybrid vine robot with internal Steering-Reeling Mechanism enhances system-level capabilities. IEEE Robotics and Automation Letters.

# New steering and retraction



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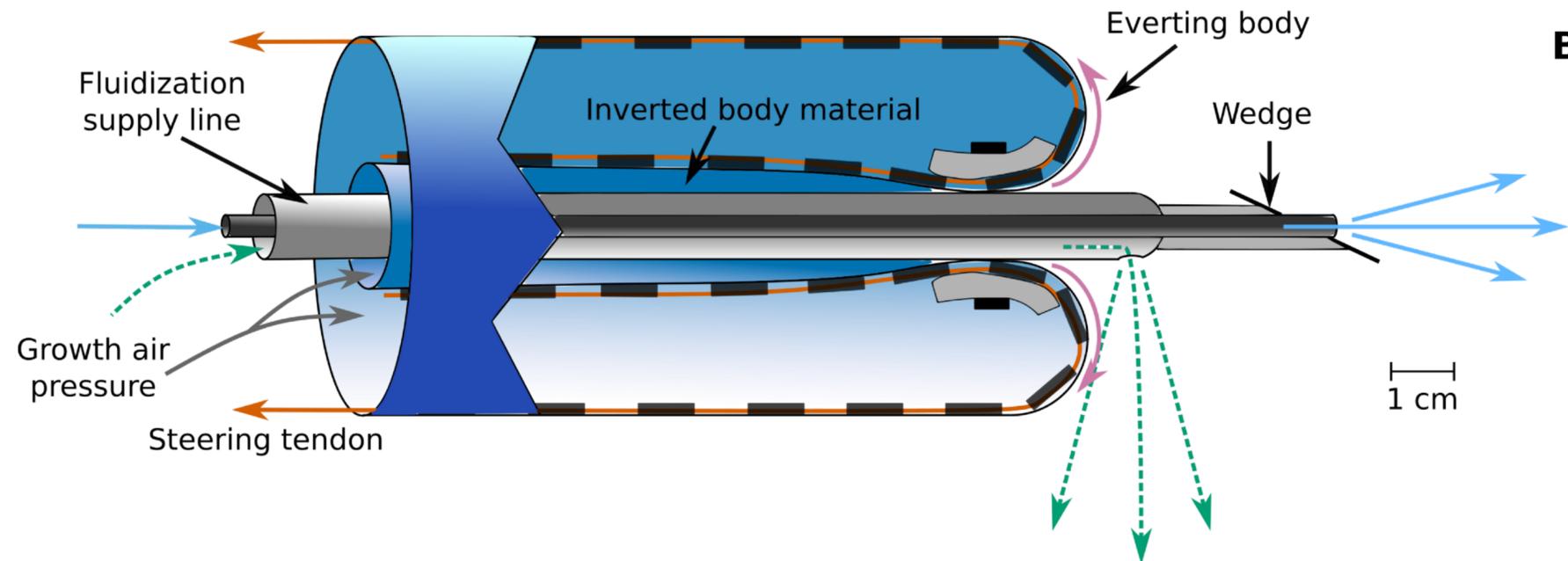
# New understanding: moving through soil



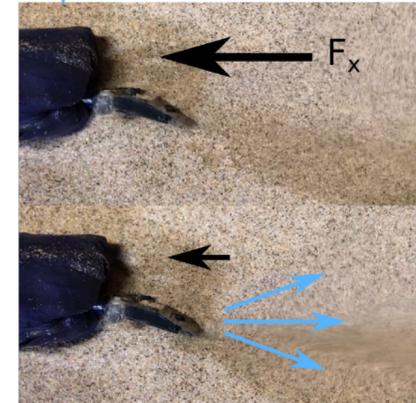
**A** Tip-extension



eliminates skin drag

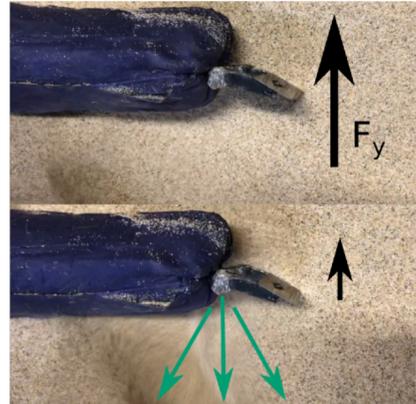


**B** Tip-based Fluidization



reduces drag force

**C** Directed Tip-flow



controls lift force

# Broader Impacts: Soft Robotics Course

Undergraduate and Graduate  
Versions

6 fully remote lab modules with  
supply list

Beta testing with collaborators at  
other schools

# Broader Impacts: Medical Apps

Endovascular Surgery  
Mechanical Thrombectomy

Urology  
Kidney Stone Removal, Sterile Catheter

Bronchoscopy/Intubation

Gastrointestinal  
Colonoscopy, Small Intestine Enteroscopy

Intubation



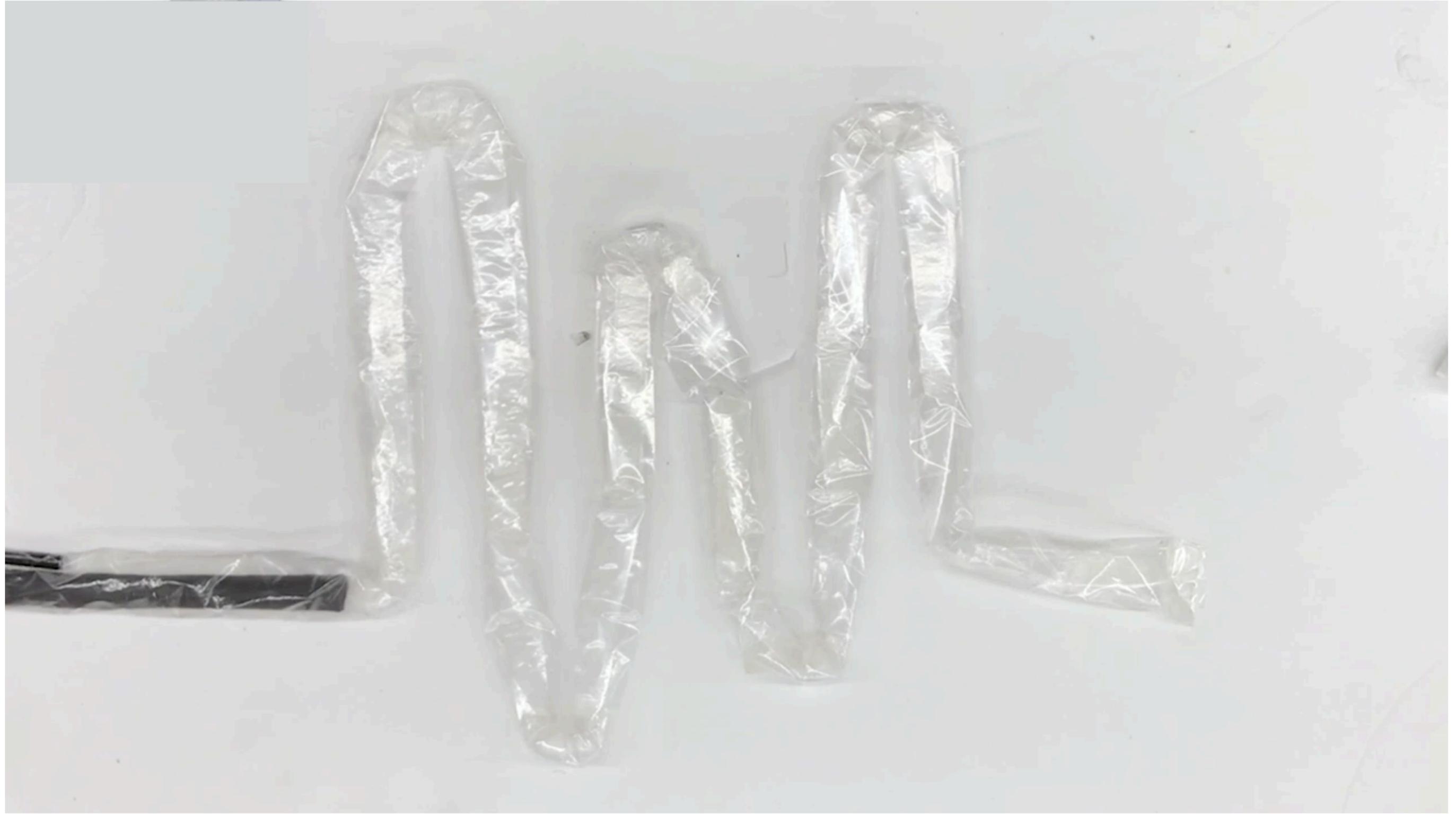
**STANFORD**  
SCHOOL OF MEDICINE

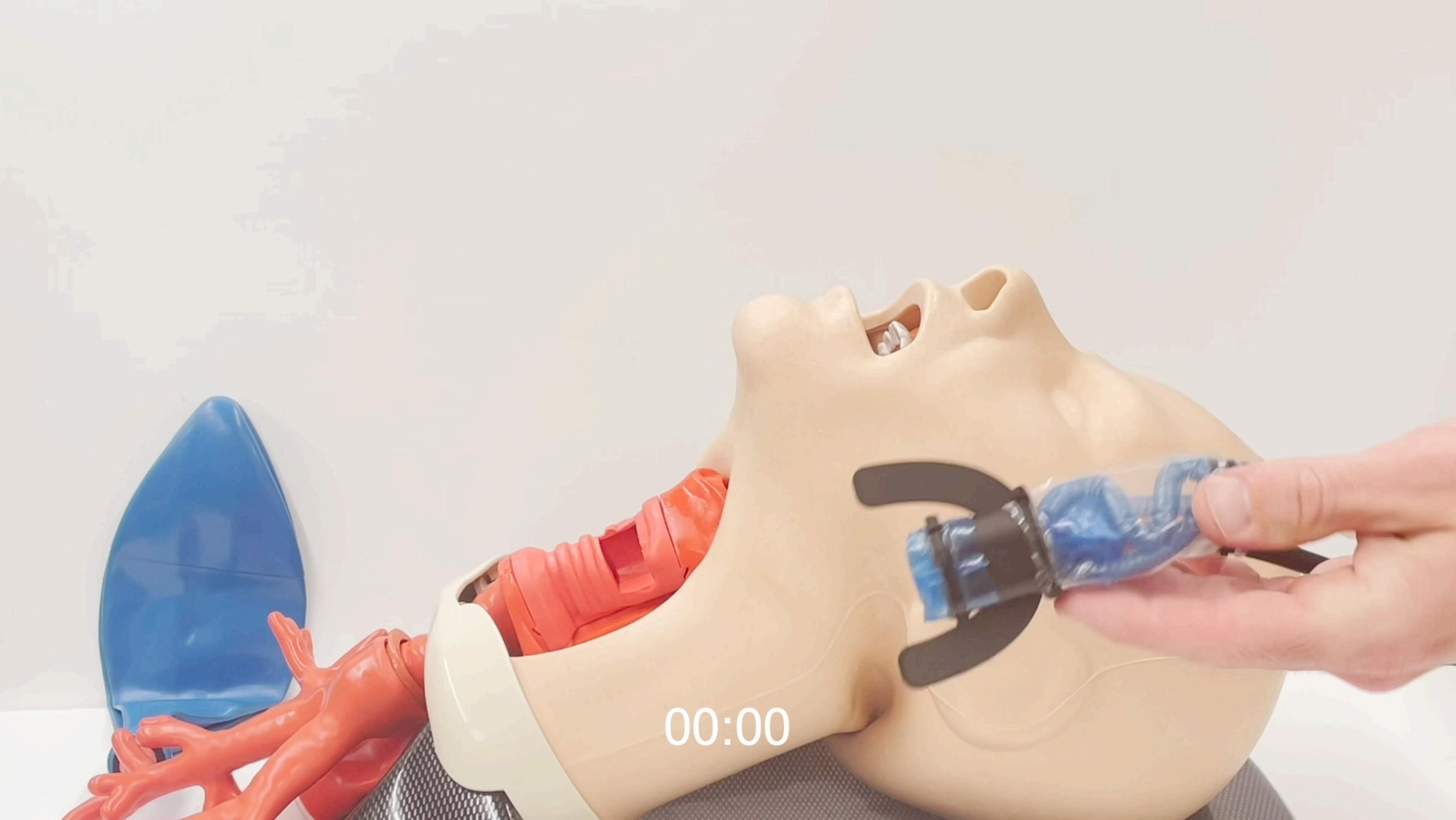
*Stanford University Medical Center*



UNIVERSITY OF WASHINGTON  
**MEDICAL CENTER**  
UW Medicine

# Medical Apps: Deep Enteroscopy





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