



# Week 11 | Lecture 12

## Soft robotics II

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# Introduction to Soft Robotics

- Soft robotics
  - Material Selection
  - Actuation
  - Sensation

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# Soft Actuation

- Soft actuators
  - systems that are compliant and flexible
  - Can used for shape changes, joining and locomotion
- Stimuli for soft actuators
  - Fluidic
  - Electrical
  - Themal
  - Chemical
  - Magnetic

# Fluidic



# Fluidic – Festo

FESTO



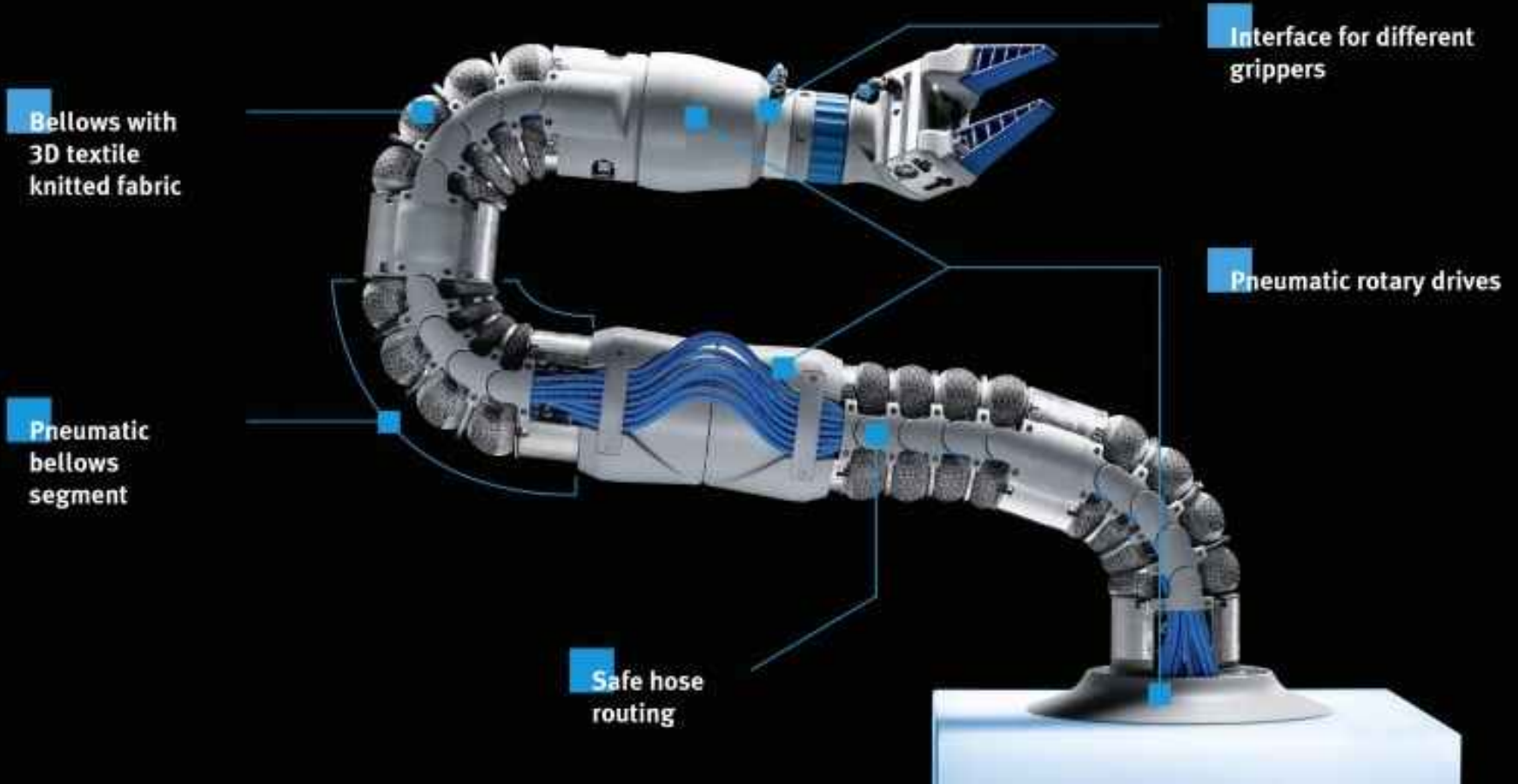
# Fluidic – Festo

Kinematics inspired by the elephant's trunk



# Fluidic – Festo

BionicSoftArm from Festo with seven pneumatic actuators



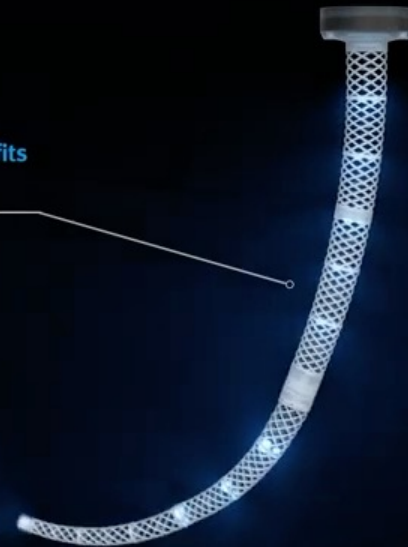
# Electrical – Festo

FESTO



### Bionic E-Trunk

Good mobility thanks to 12 g own weight with highest force-to-weight ratio.

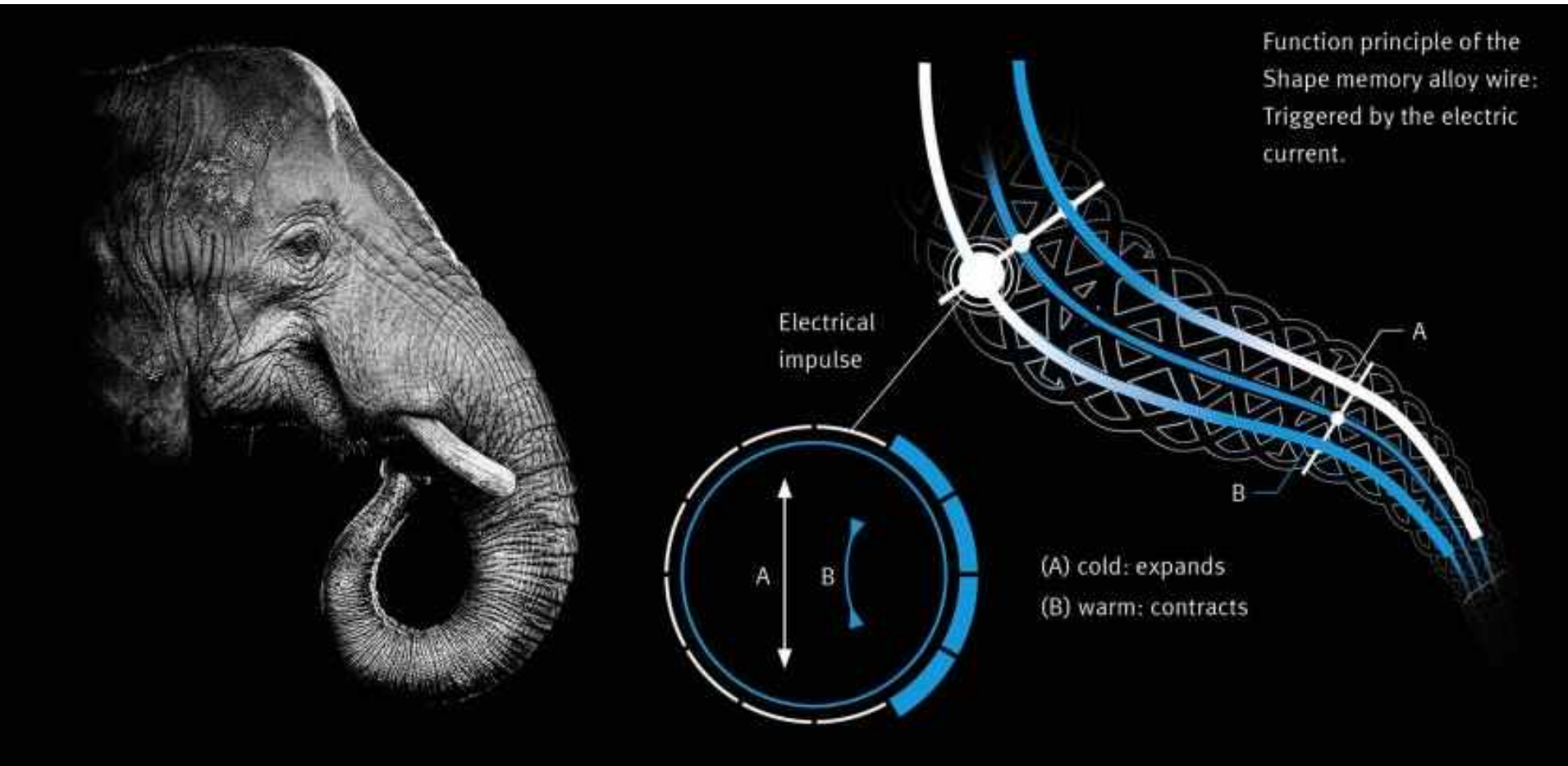


### Inspired by nature

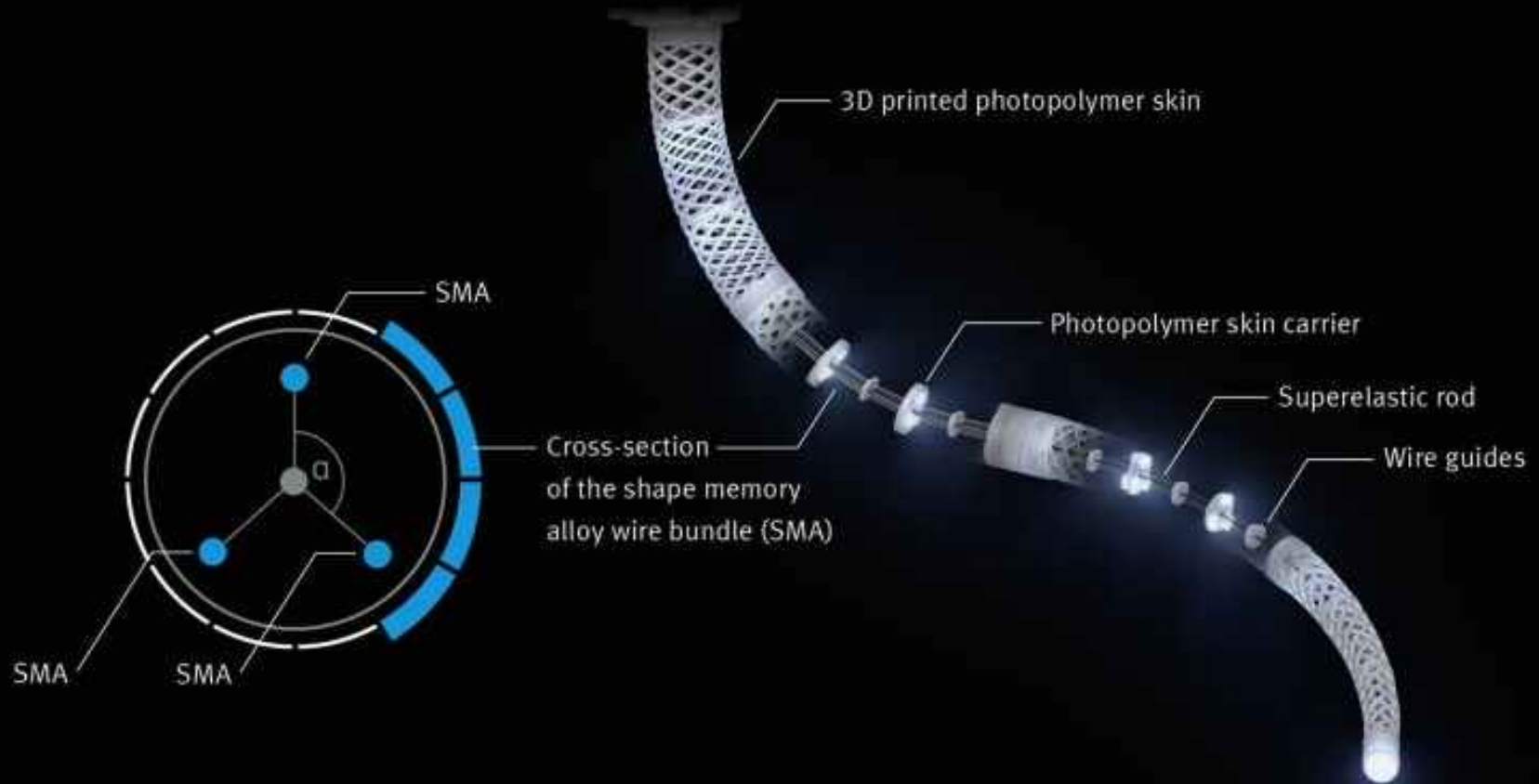
Electrical impulses cause contractions of the muscles in the trunk.



# Electrical

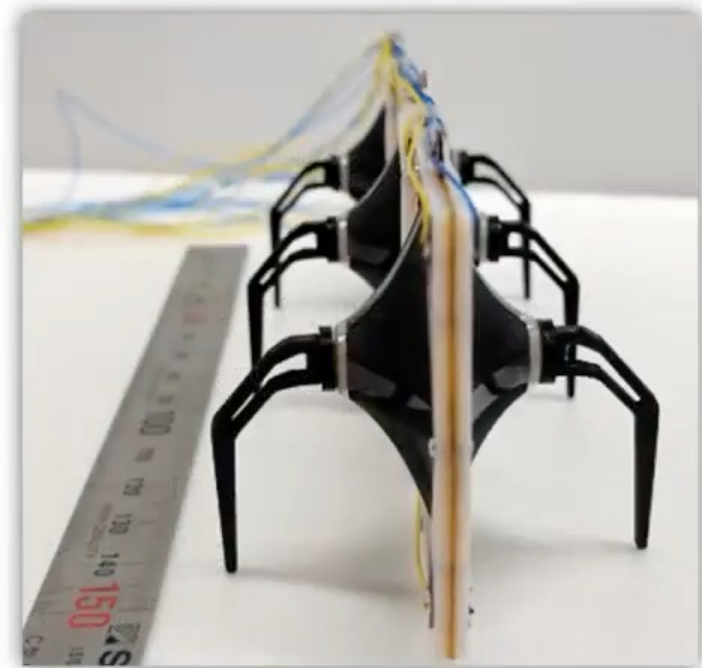
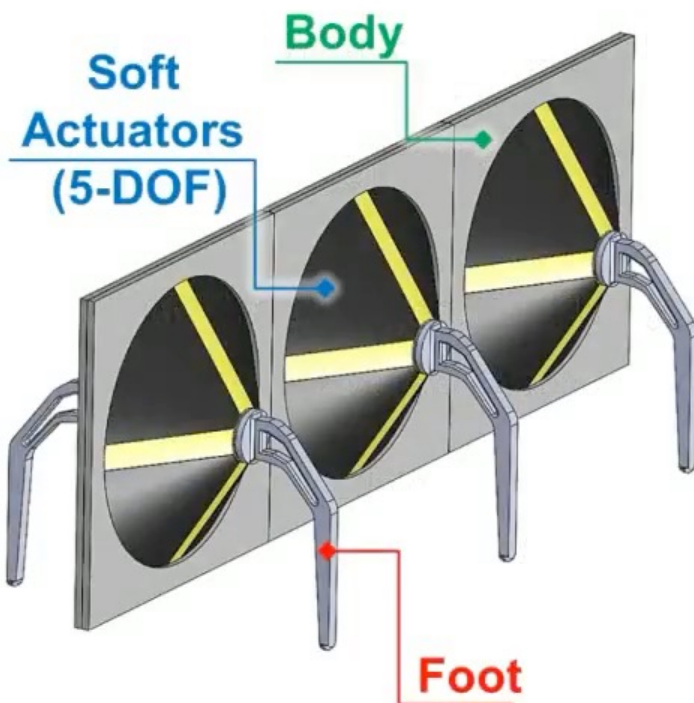


# Electrical



# Electrical

## 2<sup>nd</sup> Sungkyunkwan hexapod robot (S-Hex II)



❖ Weight: 20 g

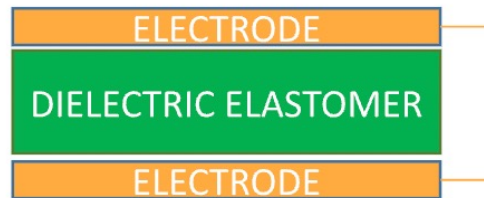
❖ 150 mm x 54 mm x 55 mm (L x W x H)

Overall design, mechanical components and prototype of the S-Hex II robot

# Electrical

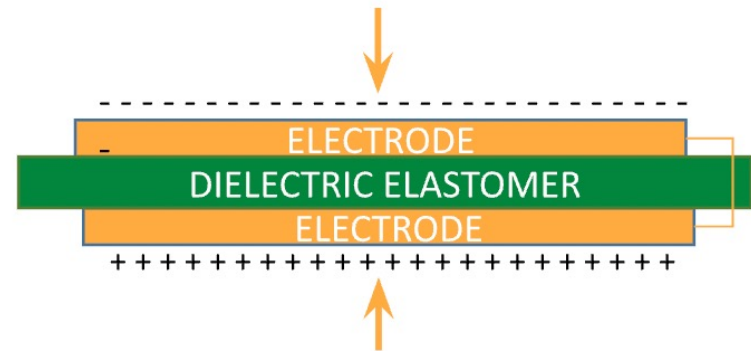
## Dielectric elastomers actuators (DEA)

Voltage off

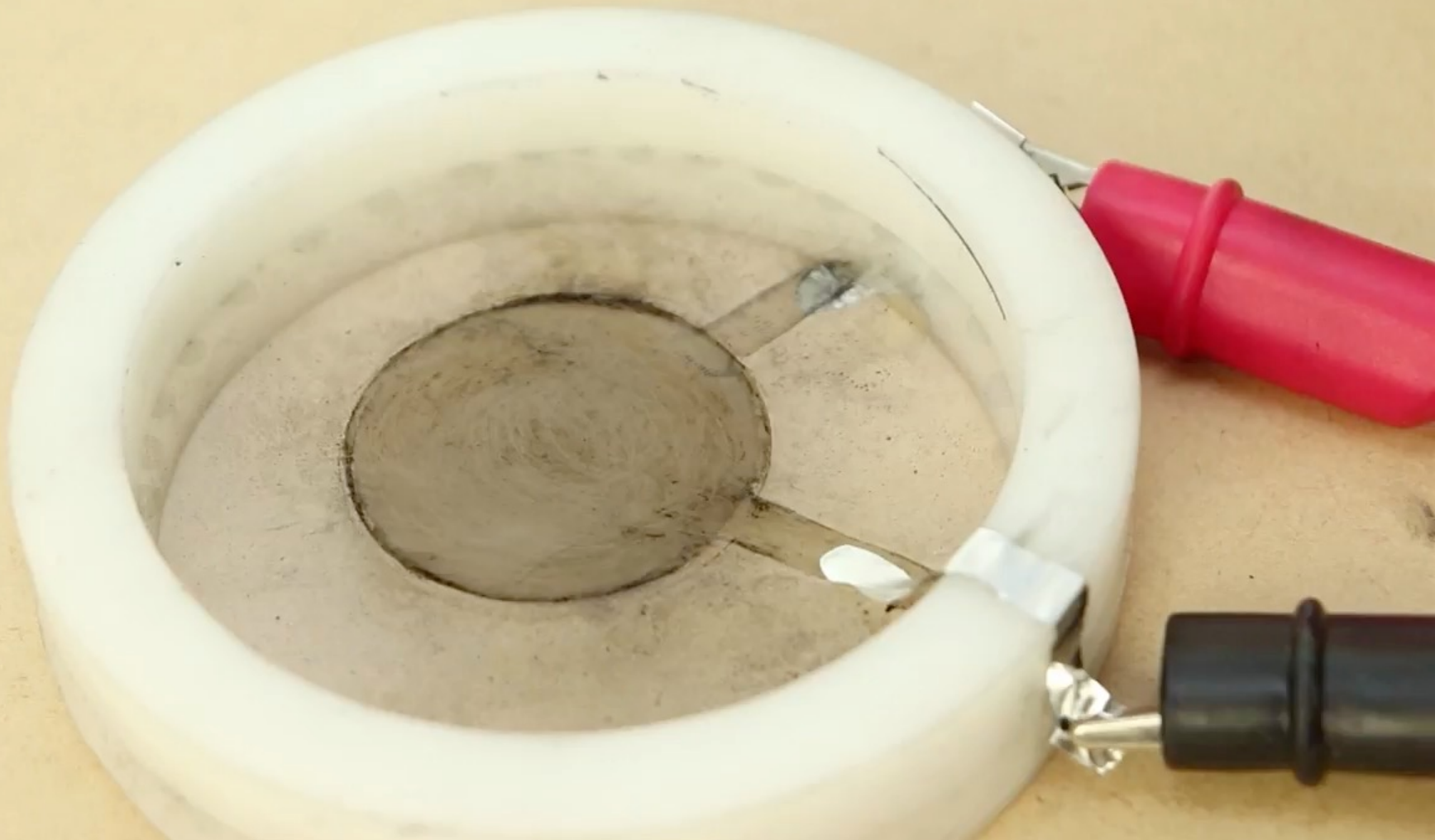


$$P = \epsilon_r \epsilon_0 \left( \frac{V}{y} \right)^2$$

Voltage on

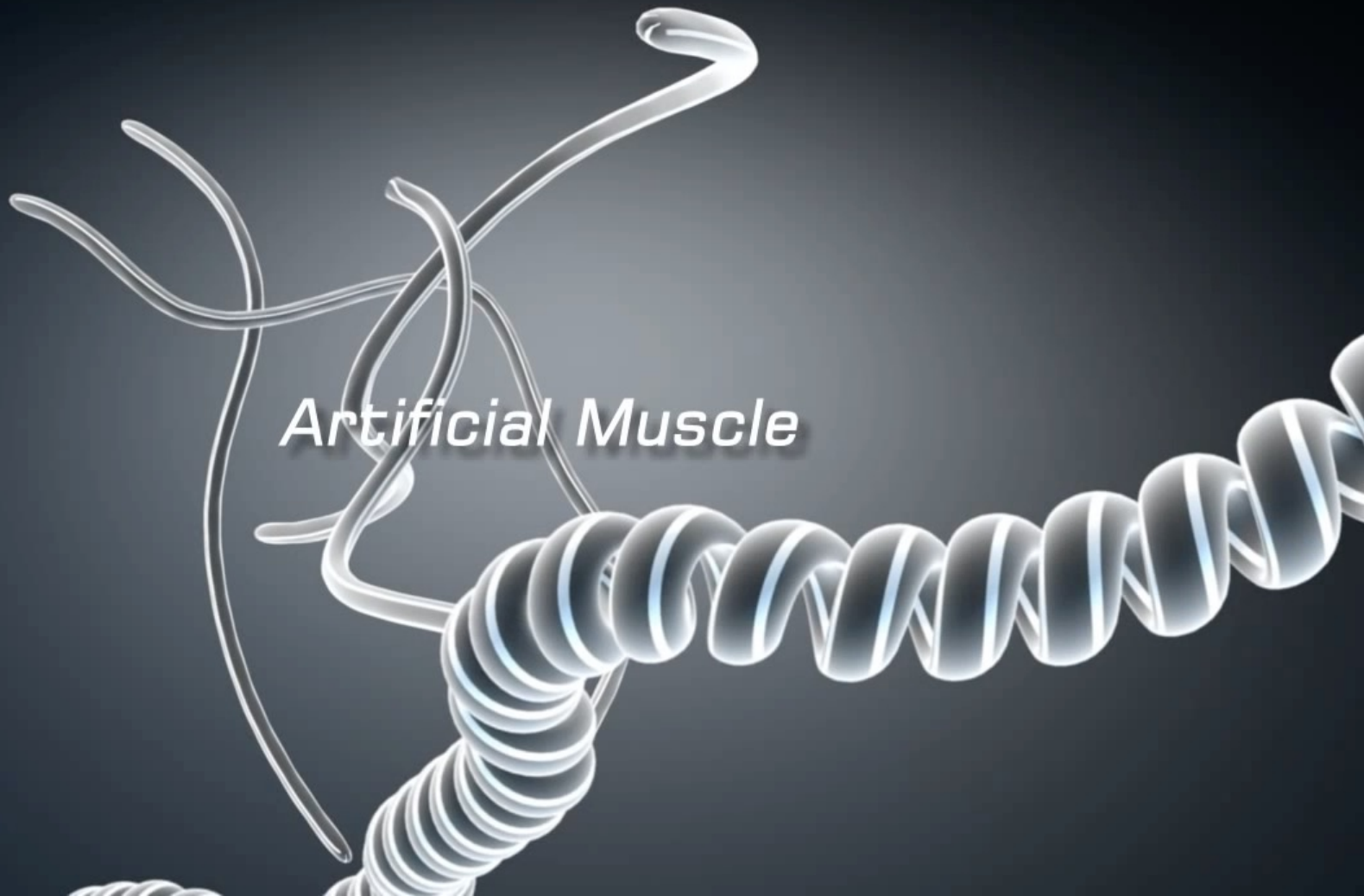


# Electrical





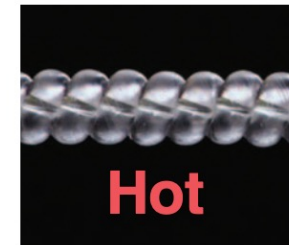
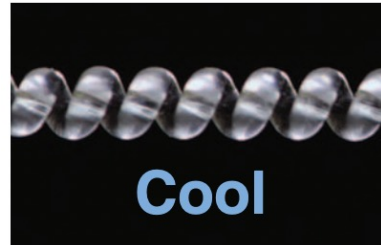
# Thermal



# Thermal



# Thermal



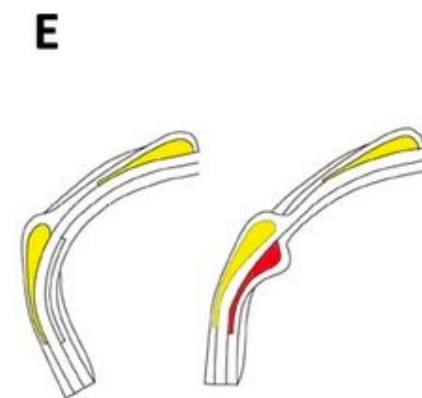
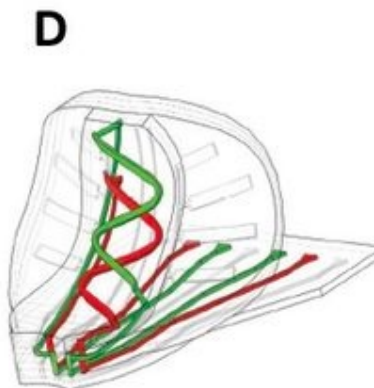
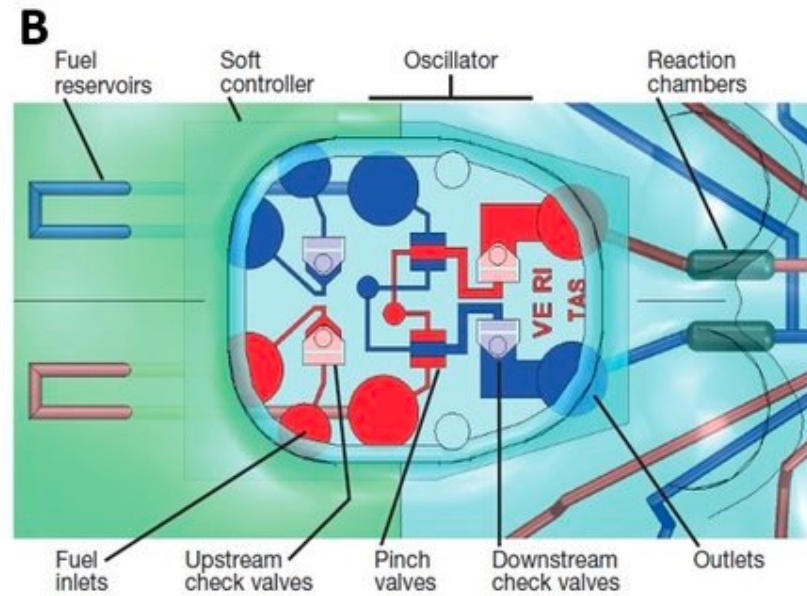
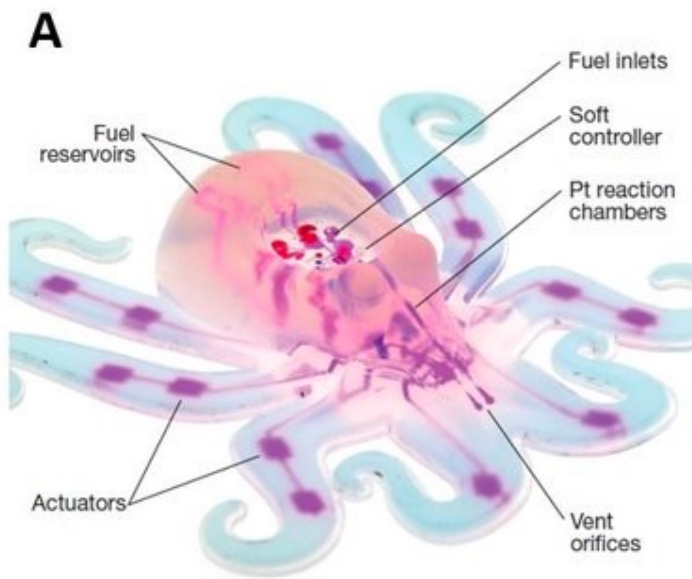


# Chemical - Octobot



Inspired by the squishy bodies of octopuses, researchers crafted the octobot's exterior out of silicone

# Chemical - Octobot



# Magnetic



# Magnetic

Dr. Mengmeng Sun/Chinese University of Hong Kong



That may take time to develop, as the **magnetic particles are toxic** and a protective layer is needed



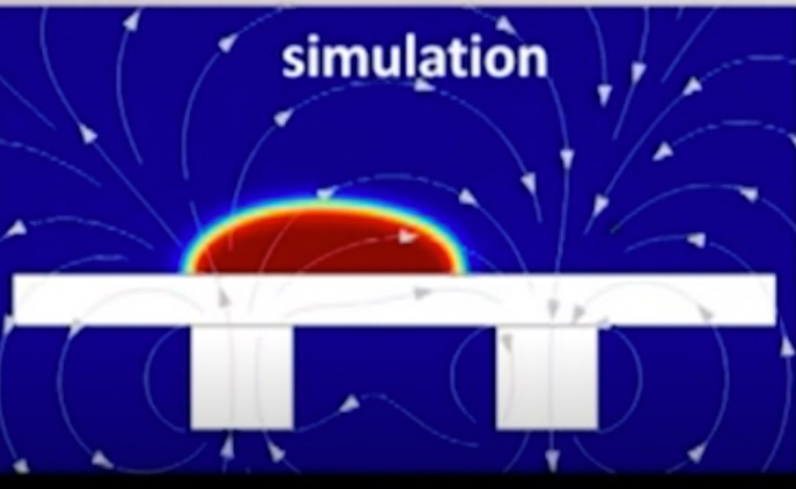
# Magnetic

experiment

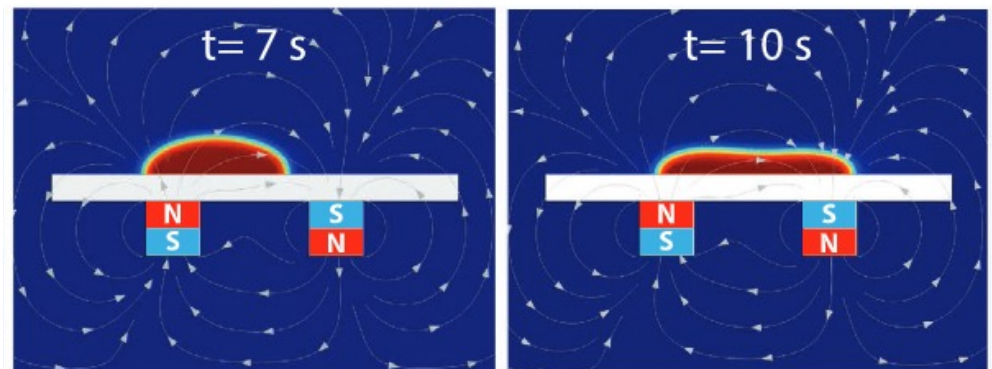
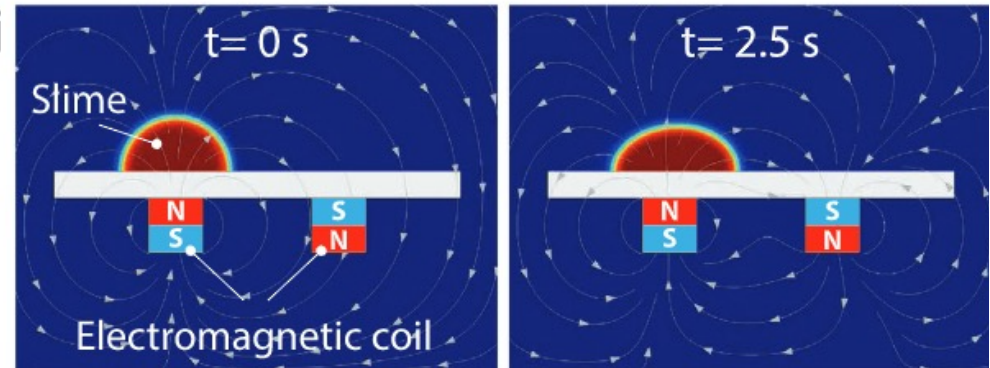


10 mm

simulation

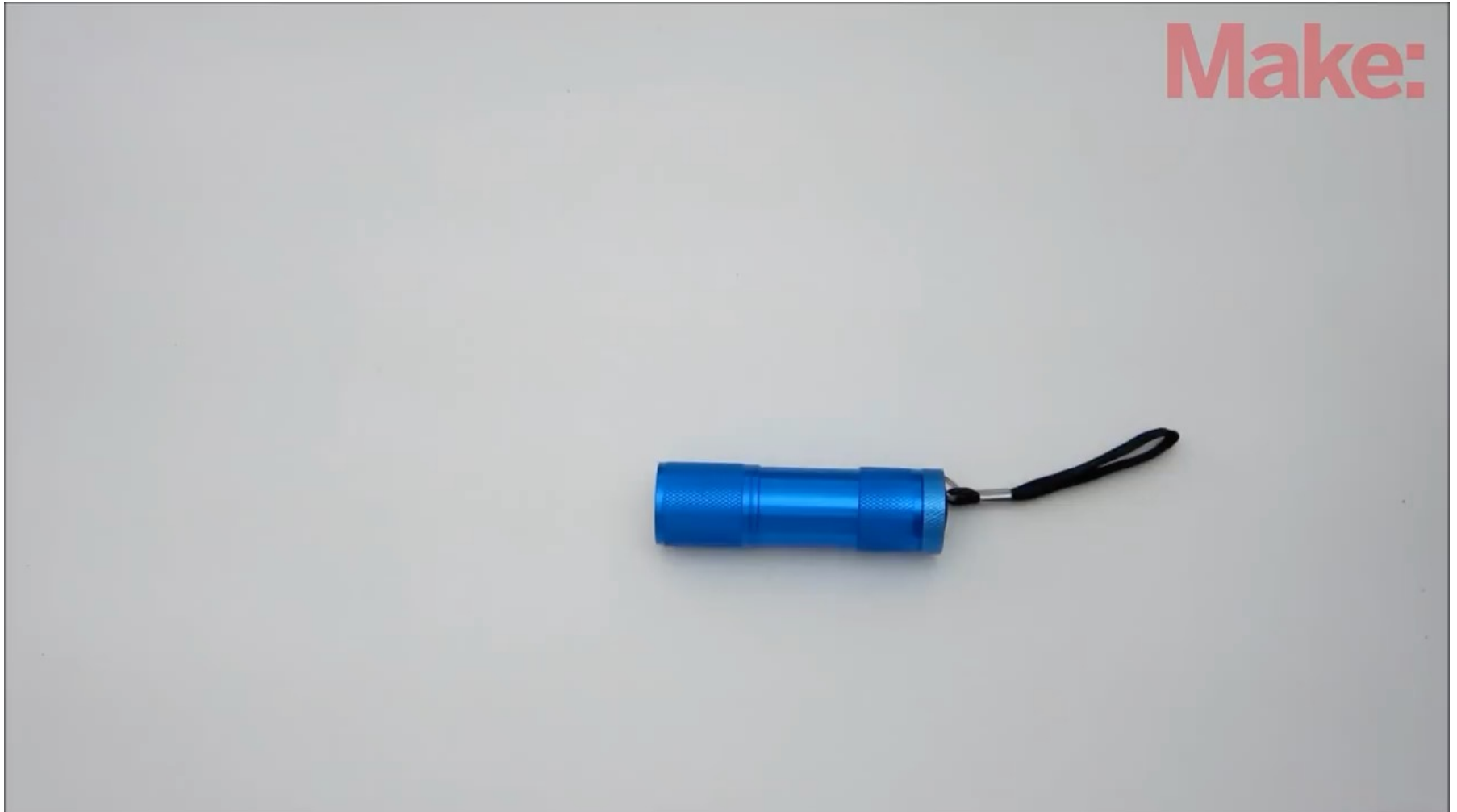


i



# Mechanisms of Actuation

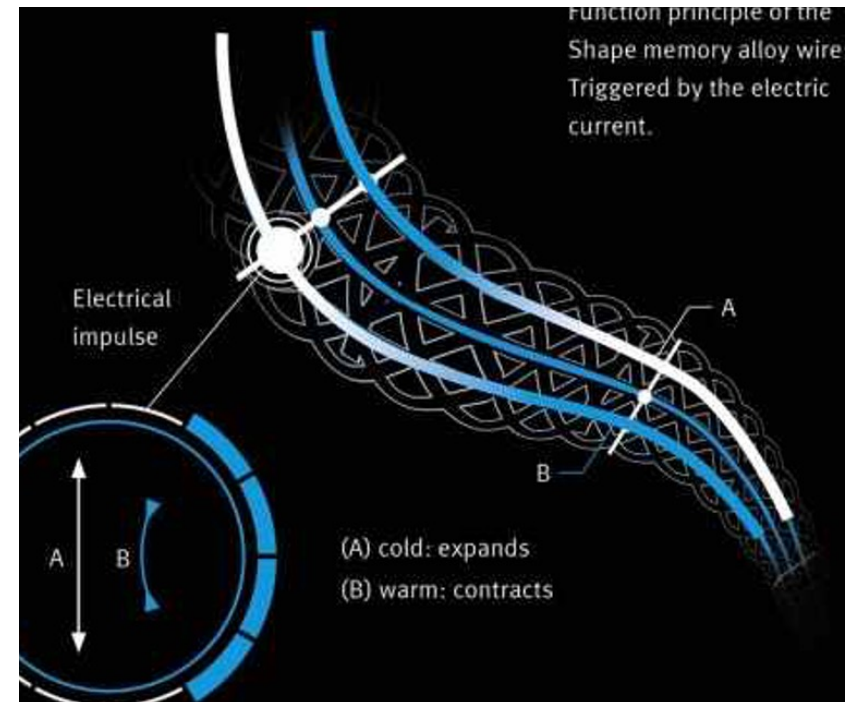
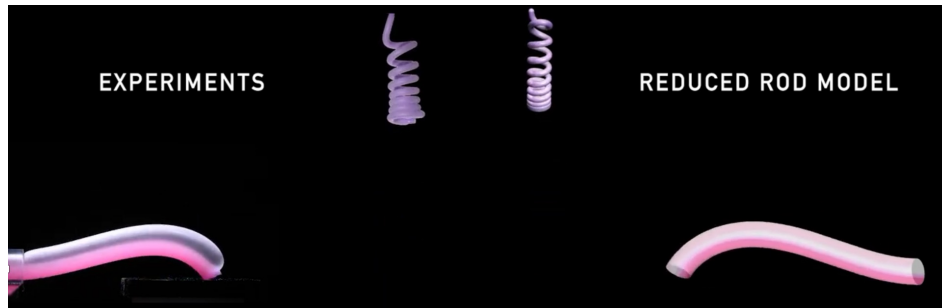
## 1. Variable Stiffness 变刚度



# Mechanisms of Actuation

## 2. Mismatch Strain 差异化变形

- Central principal in the operation of unimorph actuators
- 3D change of shape in heterogeneous materials



# Human Robot Interaction

A photograph showing a human hand on the right side, with the index finger touching a white, elongated, cylindrical pneumatic prototype. The device has a textured surface and is resting on a reflective white surface. The background is a plain, light-colored wall.

**Spatial Flux**

1/4 Pneumatic Prototype



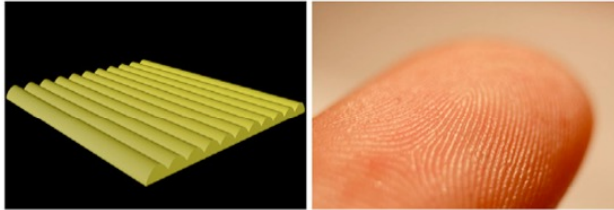
# Human Robot Interaction



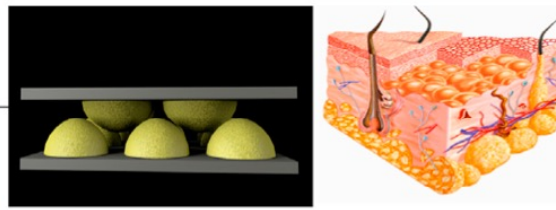
# Mechanotransduction structural and functional (motif and prototypes) in the natural world

## 自然界的机械传导结构和功能（概念与原型）

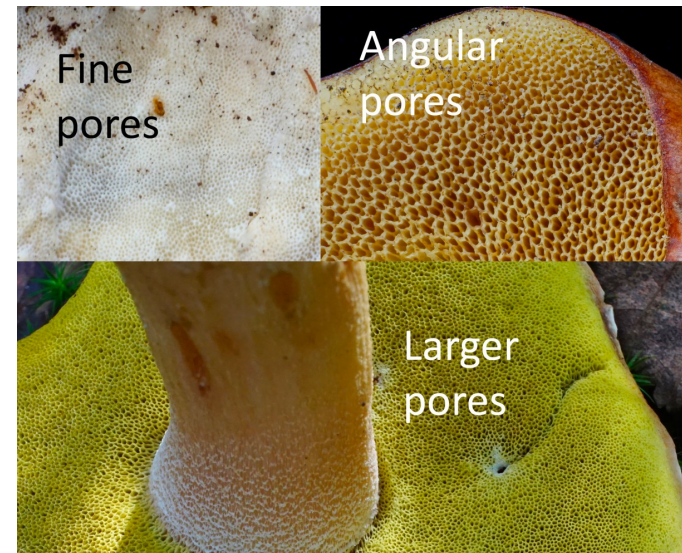
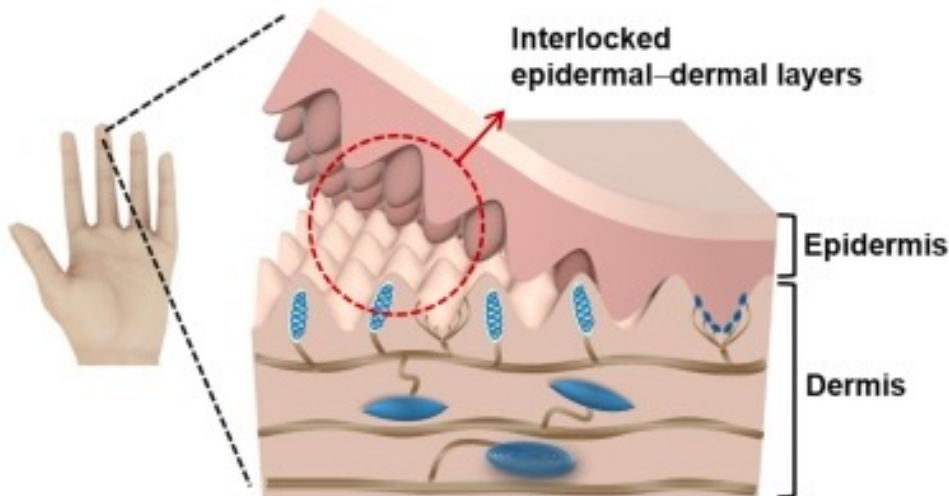
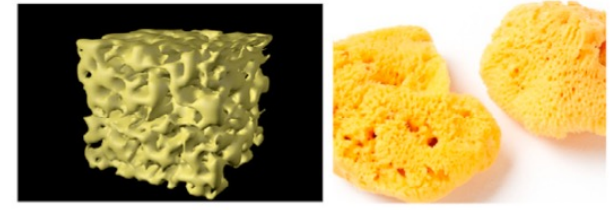
A Fingerprint structure



B Interlocked structure 联锁

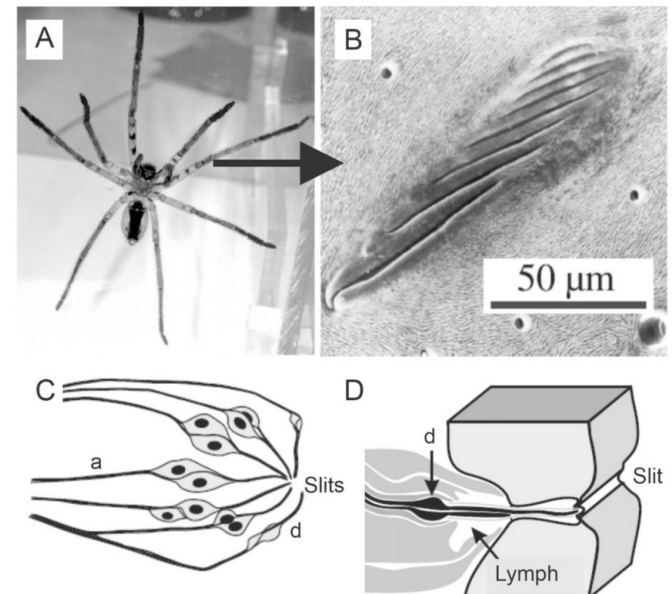
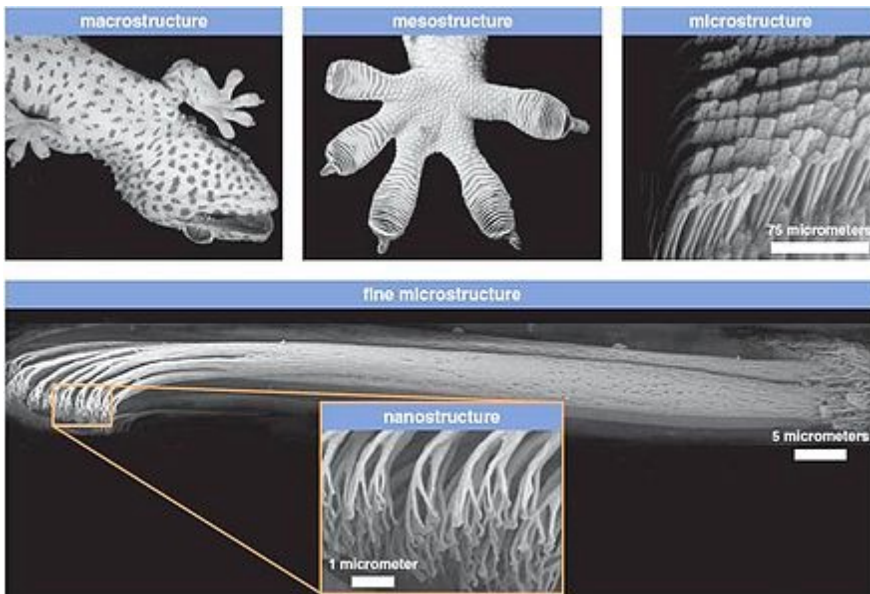
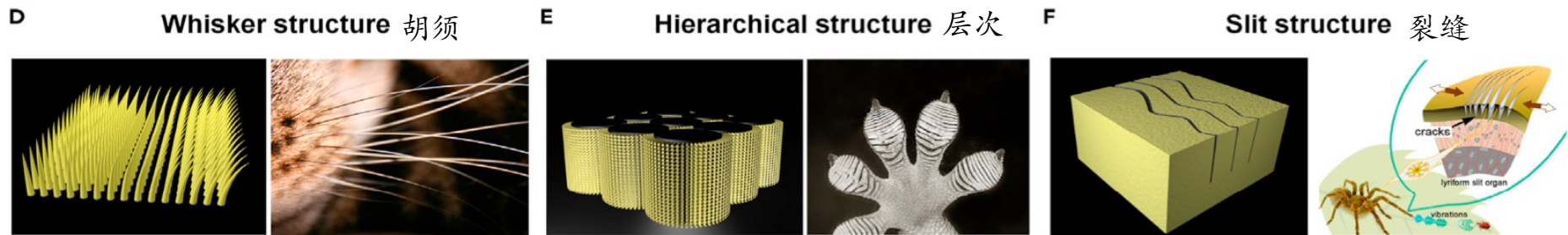


C Porous structure 多孔



# Mechanotransduction structural and functional (motif and prototypes) in the natural world

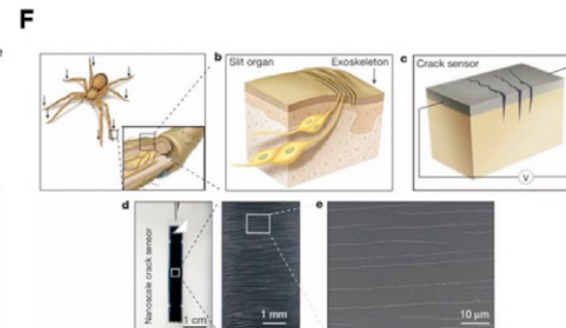
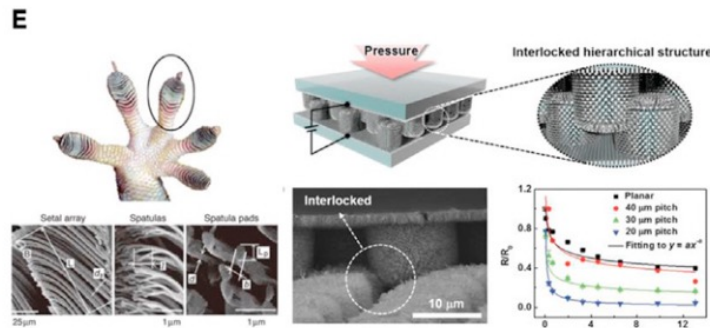
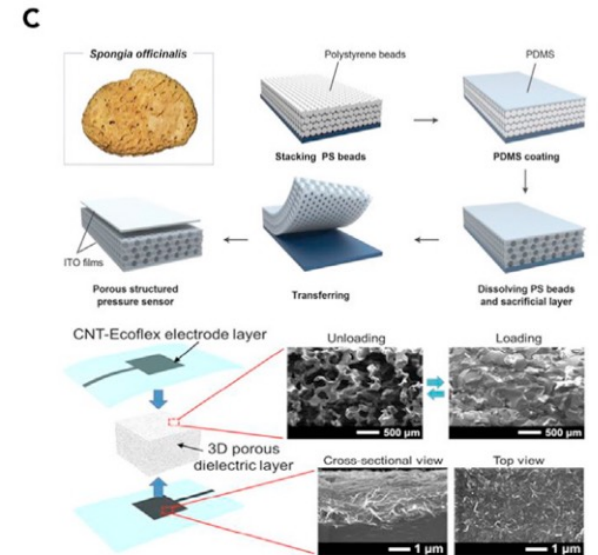
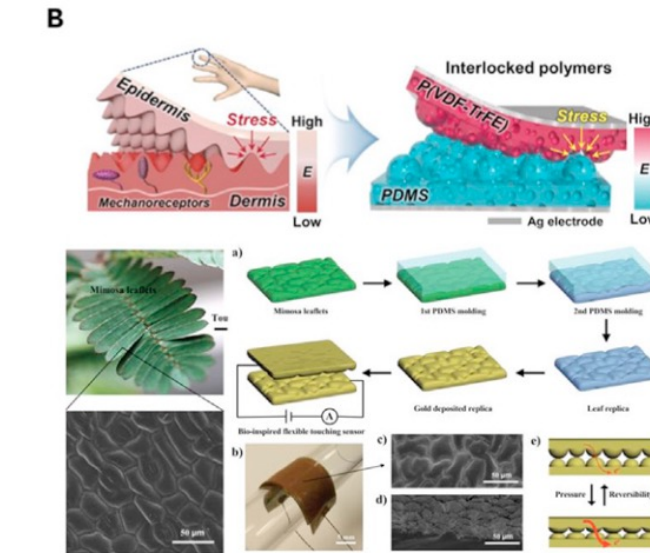
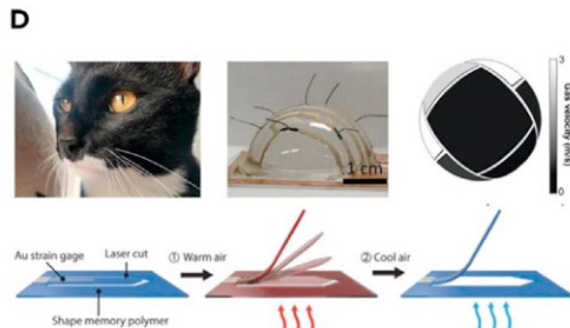
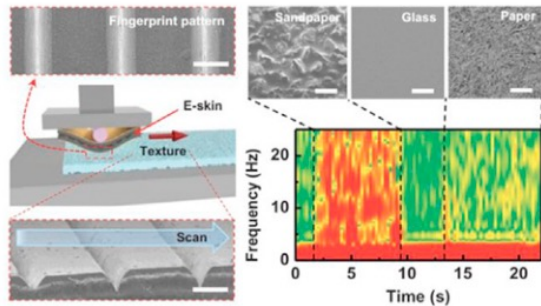
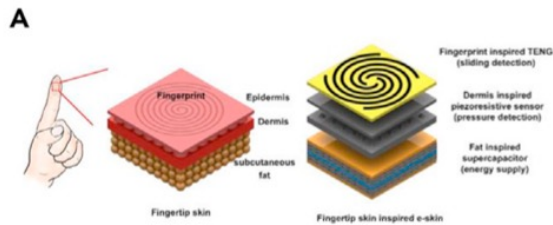
## 自然界的机械传导结构和功能（概念与原型）



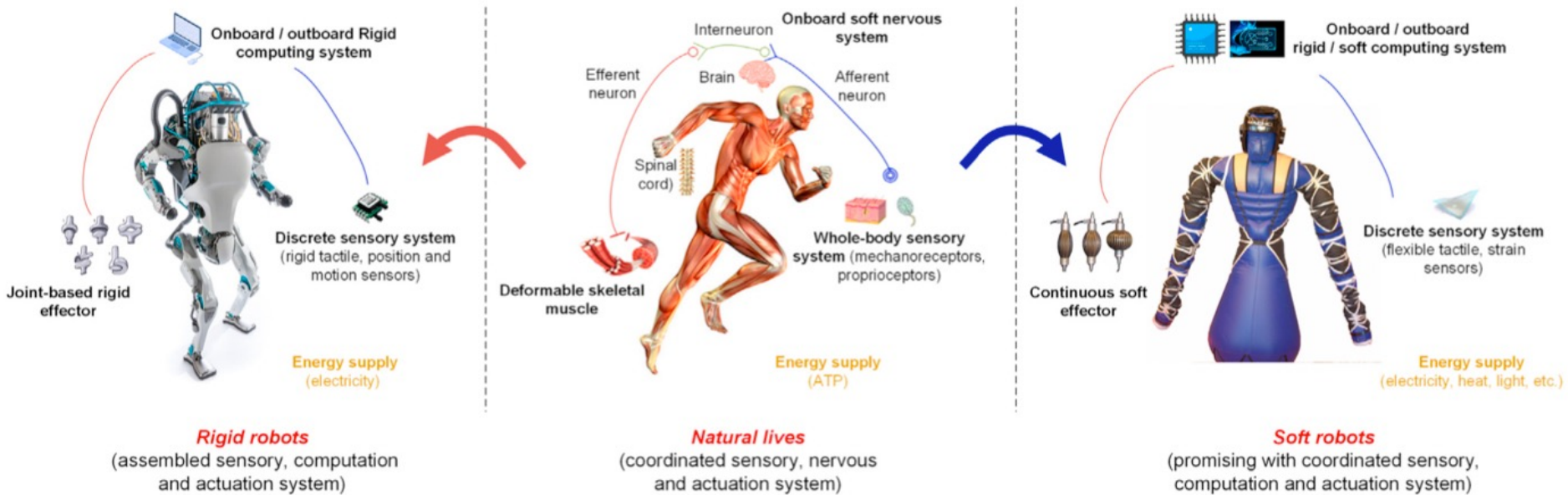


# Flexible mechanosensors inspired by biological sensory motifs

## 柔性机械传感器（受生物启发的）



## Comparison of natural lives, rigid robots, and soft robots



	Building unit	Energy efficiency	Versatility	Agility	Adaptability	System robustness	Self-healing
<b>Natural lives</b>	cell	★★★★	★★★★	★★★★	★★★★	★★★★	★★★★
<b>Rigid robots</b>	Metal, polymer, silicon, etc.	★★	★	★★	★	★	★
<b>Soft robots</b>	Polymer, hydrogel, etc.	★	★★	★	★★	★	★★

★★★★ Excellent  
 ★★★ Average  
 ★ Promising

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# Next week (12)

- (20%) Project: Team Final Poster on the Design of a Reachy Part
  - Explain the design and working principle of your team's portion of Reachy
  - Formulate and explain a step-by-step assembly for your team's portion of Reachy
  - Explain and justify the use of Generative Design on improving a selected part from Fusion and **send for 3D printing before 2nd Dec.**



# DES 5002: Designing Robots for Social Good

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Autumn 2022

**Thank you~**

Wan Fang

Southern University of Science and Technology