Biologically-derived Materials for Powering Next Generation Biomedical Electronics

Young Jo Kim, Ph.D.
Assistant Professor
Department of Chemical Engineering
University of New Hampshire

kimlab

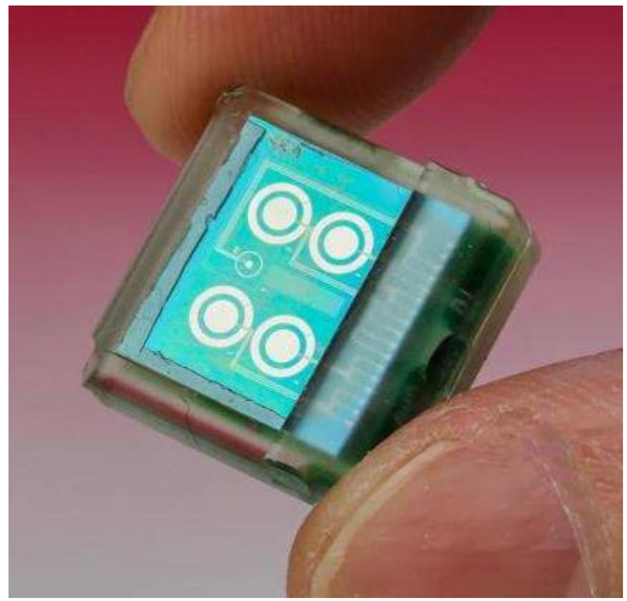
University of New Hampshire

Implantable biomedical devices

Tissue stimulation

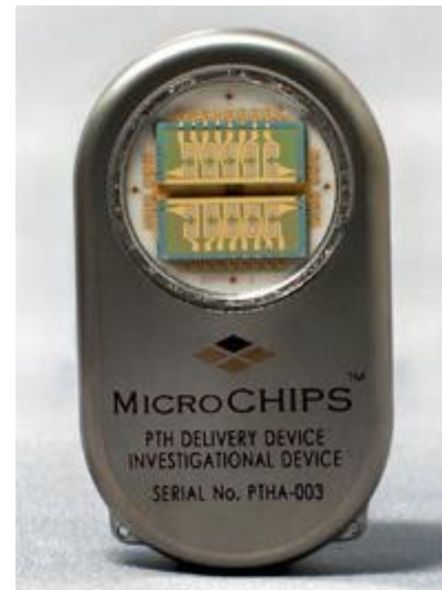
Stimulate deep brain for treating obesity

Biosensor



Monitor pH, T, and glucose

Controlled release



Deliver drugs

Challenges with implantable devices

What if we could build the devices...

Infection

Reduce infection risk

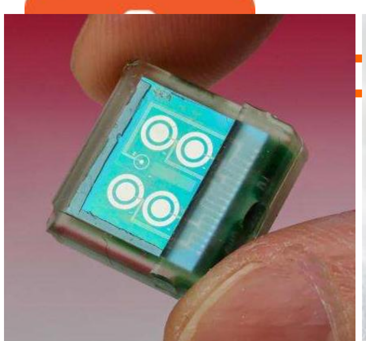
Chronic inflammation

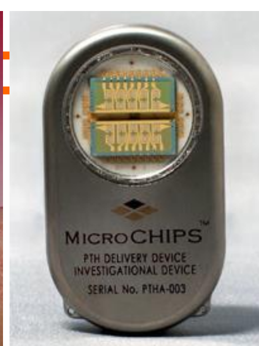
Temporary

Costly surgeries

Cost-effective deployment

F ce batteries





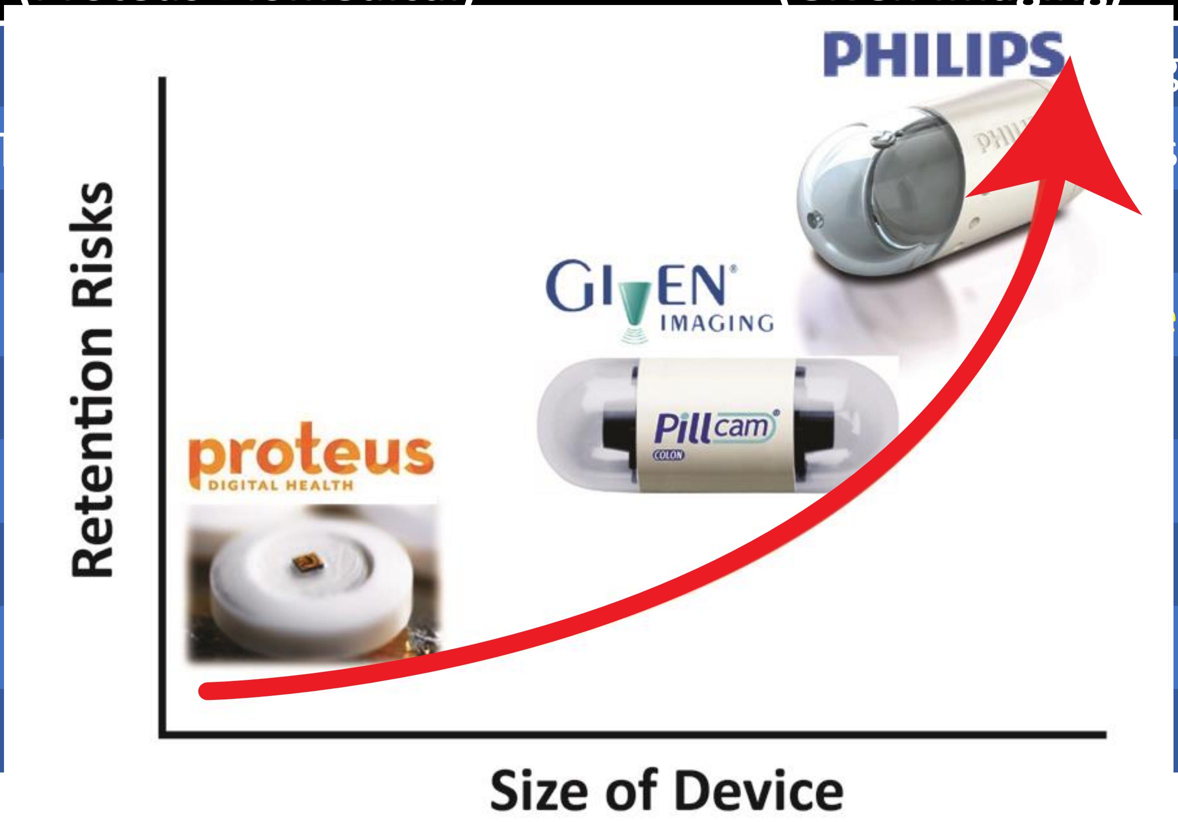
Why Edible Electronics?

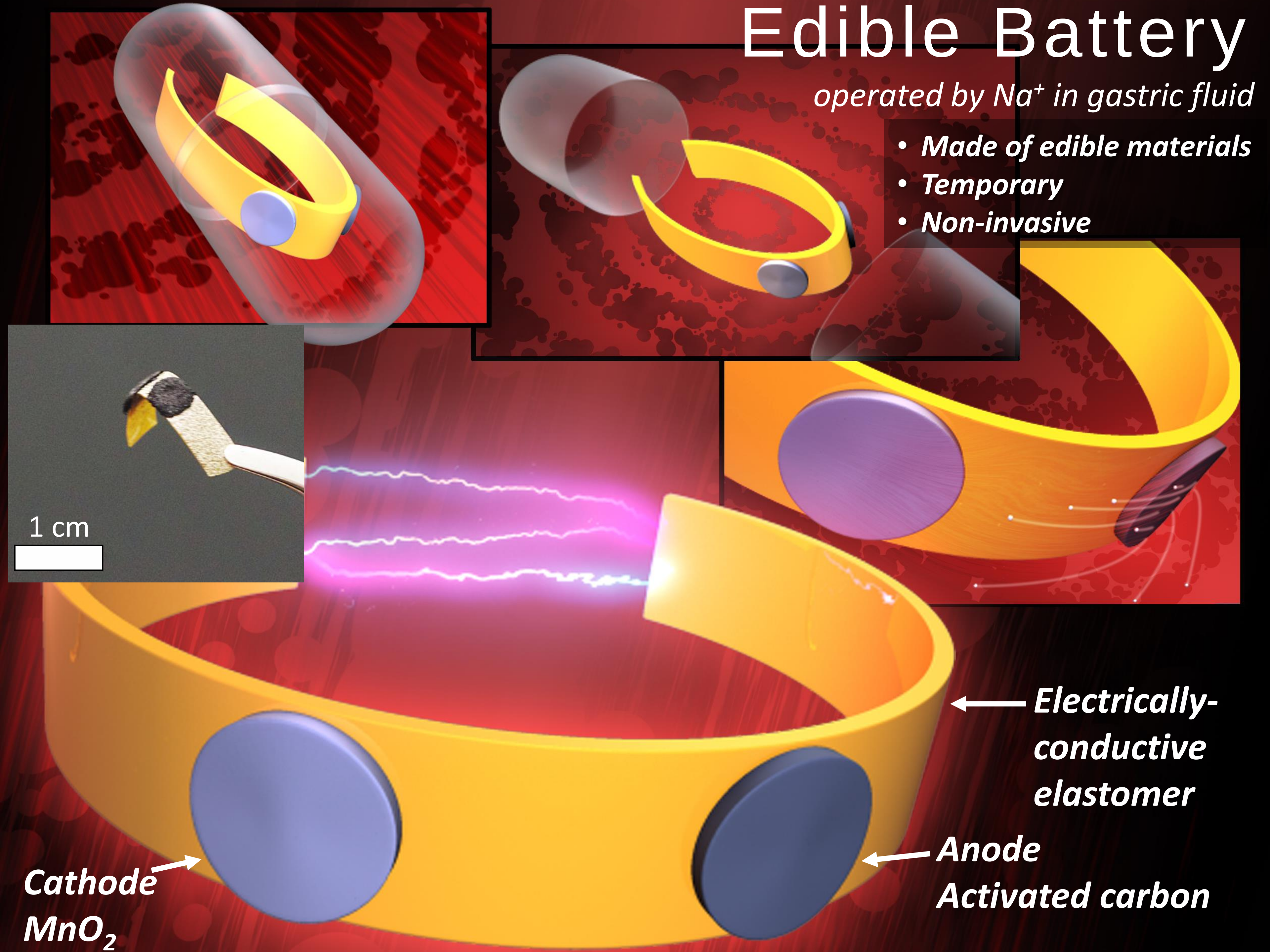
Most people feel comfortable with taking pills.

- **Balance of functional device lifetime with rapid deployment**
- **Non-invasive, high patient compliance**
- **Reduced sterilization burden**
- **Obviate issues associated with chronic implants**

Device comparison

	Helius (Proteus Biomedical)	PillCam (Given Imaging)
Indication		g
Function	T	sfer
Device lifetime		
Power source		es
Logic elements		
Packaging		
Size (D x L)		
Mass		
Retention risk		





Edible Battery
operated by Na+ in gastric fluid
• Made of edible materials
• Temporary
• Non-invasive
1 cm
Electrically-conductive elastomer
Anode
Activated carbon
Cathode
MnO2

Ideal electrodes for edible electronics

Reliability *Safety*

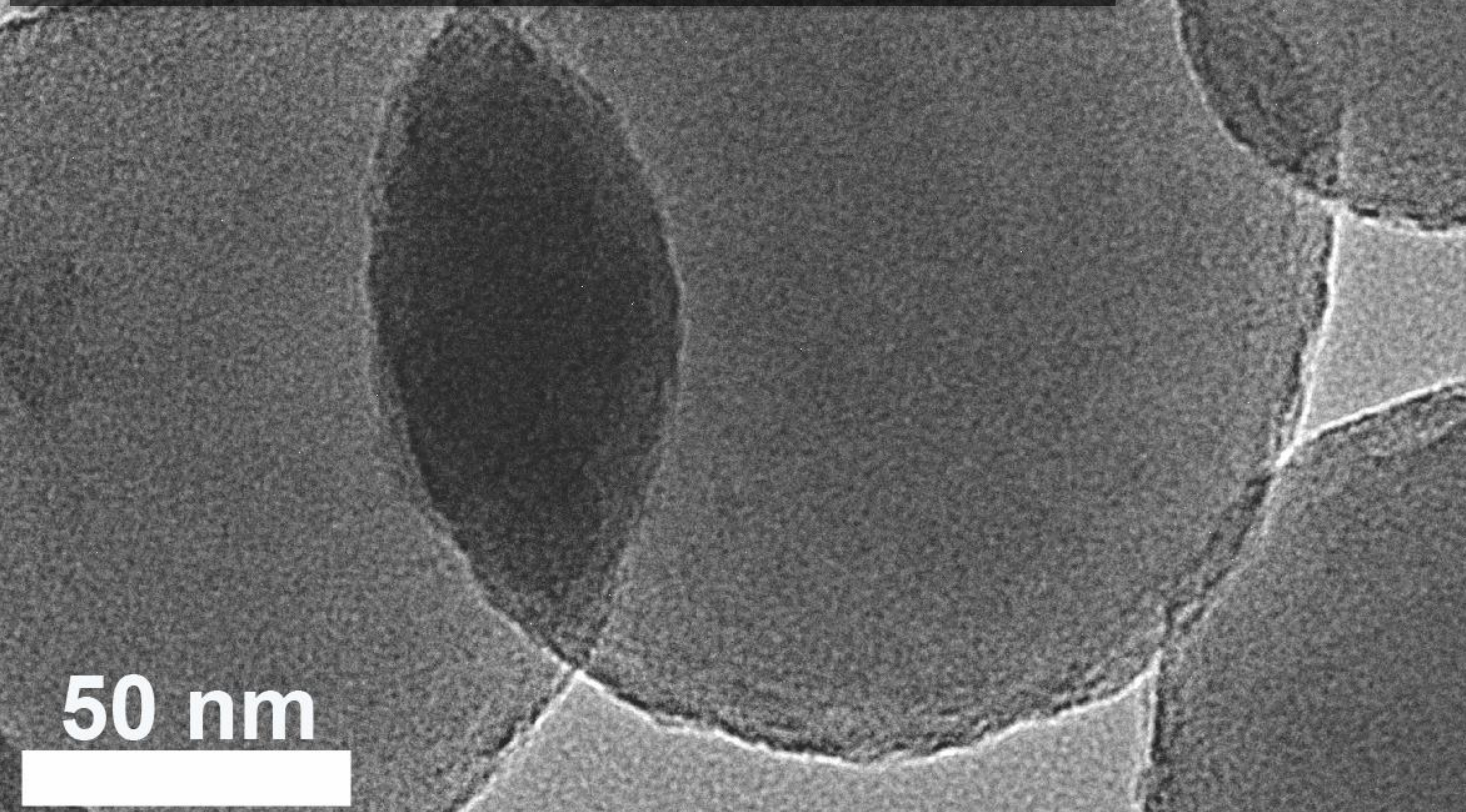
+ Long operational lifetimes
+ Robust performance
+ Manufacturing

+ Possible bioabsorption
+ Reduced risk of event
+ Materials of known risk

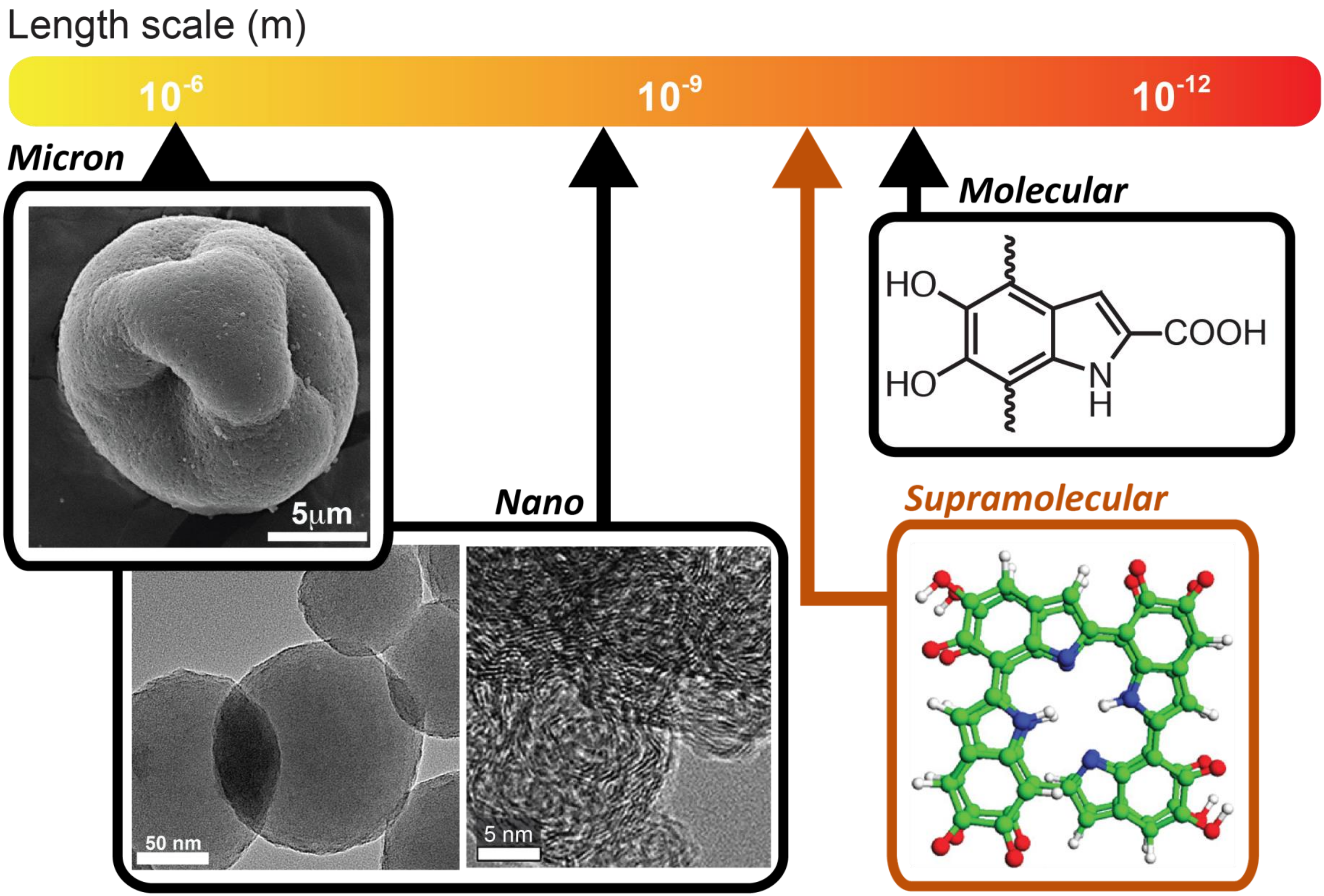
Inspired by *cuttlefish* ink

Eumelanins from cuttlefish (*sepia officinalis*)

- Homogeneous nanostructure (diameter= ~100nm)
- Stable (non-soluble) in aqueous solution
- Hydration dependent electronic-ionic hybrid conductivity



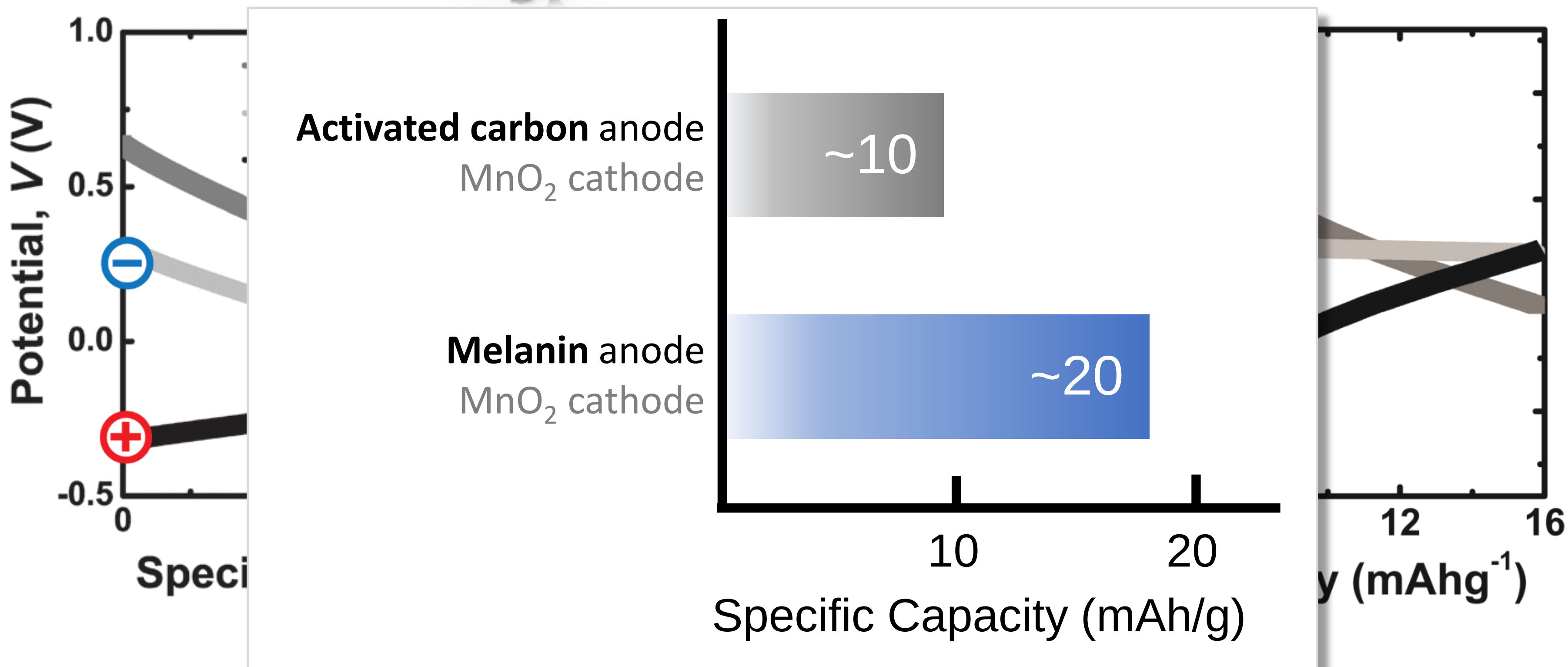
Eumelanins in multi-scale



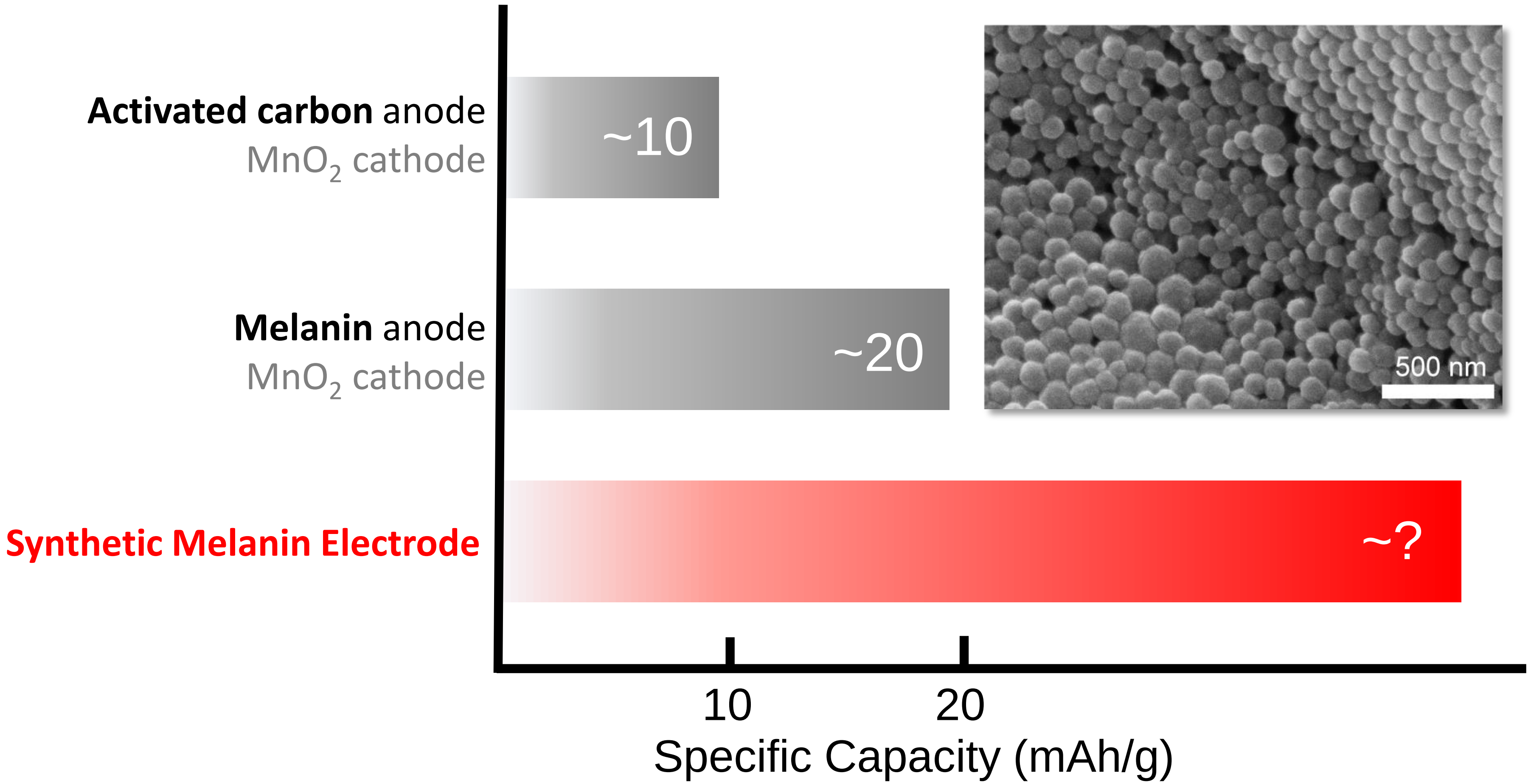
Is eumelanin a viable solution?

Activated carbon anode
MnO_2 cathode

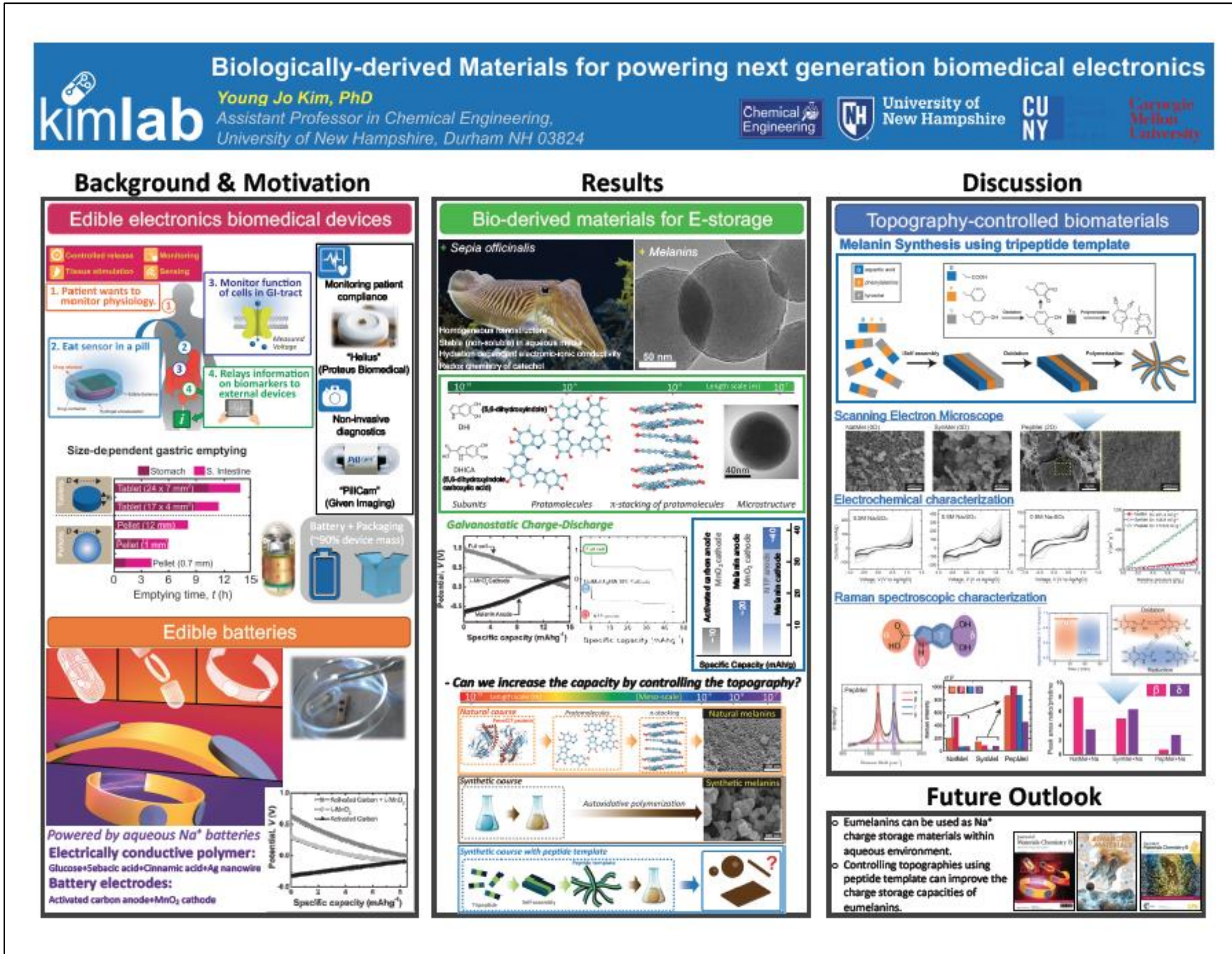
Melanin anode
MnO_2 cathode



Can we tune the capacity?



[P1801-02]


Biologically-derived Materials for powering next generation biomedical electronics
kimlab
Young Jo Kim, PhD
Assistant Professor in Chemical Engineering,
University of New Hampshire, Durham NH 03824
Chemical Engineering
University of New Hampshire
CU NY
Background & Motivation
Results
Discussion
Edible electronics biomedical devices
1. Patient wants to monitor physiology.
2. Eat sensor in a pill
3. Monitor function of cells in GI-tract
4. Relays information on biomarkers to external devices
Monitoring patient compliance
"Helius" (Proteus Biomedical)
Non-invasive diagnostics
"PillCam" (Given Imaging)
Size-dependent gastric emptying
Stomach
S. Intestine
Pellet (0.7 mm)
Emptying time, t (h)
Battery + Packaging (~90% device mass)
Edible batteries
Powered by aqueous Na+ batteries
Electrically conductive polymer:
Glucose+Sebacic acid+Cinnamic acid+Ag nanowire
Battery electrodes:
Activated carbon anode+MnO2 cathode
Specific capacity (mAhg-1)
Bio-derived materials for E-storage
Sepia officinalis
Melanins
Subunits
Protomolecules
π-stacking of protomolecules
Microstructure
Galvanostatic Charge-Discharge
Specific capacity (mAhg-1)
Specific Capacity (mAh/g)
- Can we increase the capacity by controlling the topography?
Natural course
Natural melanins
Synthetic course
Autoxidative polymerization
Synthetic melanins
Synthetic course with peptide template
Topography-controlled biomaterials
Melanin Synthesis using tripeptide template
Scanning Electron Microscope
Electrochemical characterization
Raman spectroscopic characterization
Future Outlook
Eumelanins can be used as Na+ charge storage materials within aqueous environment.
Controlling topographies using peptide template can improve the charge storage capacities of eumelanins.

Thank you

University of New Hampshire

kimlab