



JOHNS HOPKINS

WHITING SCHOOL  
of ENGINEERING

# Dogbone of the Week

Daniel Magnuson

# Endoliths!

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LETTER | JUNE 01, 2021

## On the formation of arrays of micro-tunnels in pyrope and almandine garnets ✓

Jacques Rabier; Arthur H. Heuer; Kevin J. Hemker ✱

American Mineralogist (2021) 106 (6): 1026–1029.



# Japanese Spider Crabs

- Longest limbs on any arthropod. 12 feet!
- Weighs up to 19 kg
- Live at depths of 50-600 m (pressures up to 195 elephants/Daniel)



# Crab Exoskeletons!

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## Structure and mechanical properties of crab exoskeletons

Po-Yu Chen \*, Albert Yu-Min Lin, Joanna McKittrick, Marc André Meyers

*Department of Mechanical and Aerospace Engineering and Materials Science and Engineering Program,  
University of California, San Diego, La Jolla, CA 92093-0411, USA*

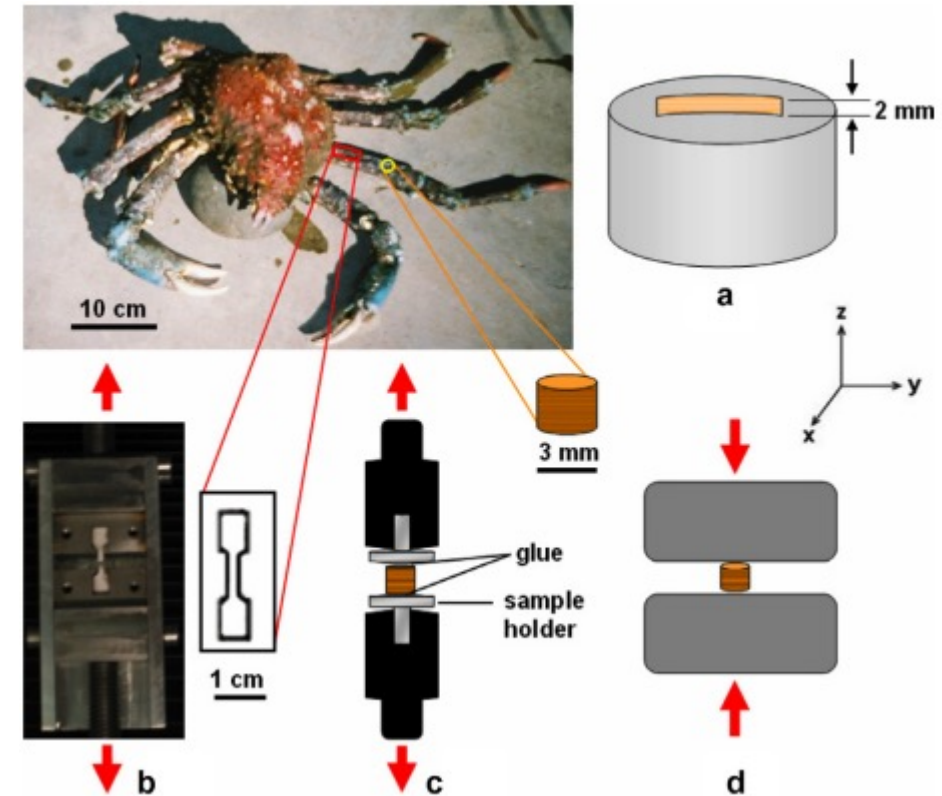
# Tests + Characterization Performed

- California sheep crabs are the species examined in this study
- Vickers indentation on cross sectional areas from claws + legs
- Tensile testing of longitudinal leg sections in wet and dry conditions
- Compressive testing of leg sections in wet and dry conditions
- Tensile testing of different layers of the shell
- Characterization of fracture surface in SEM



# Bizarre Sample Preparation

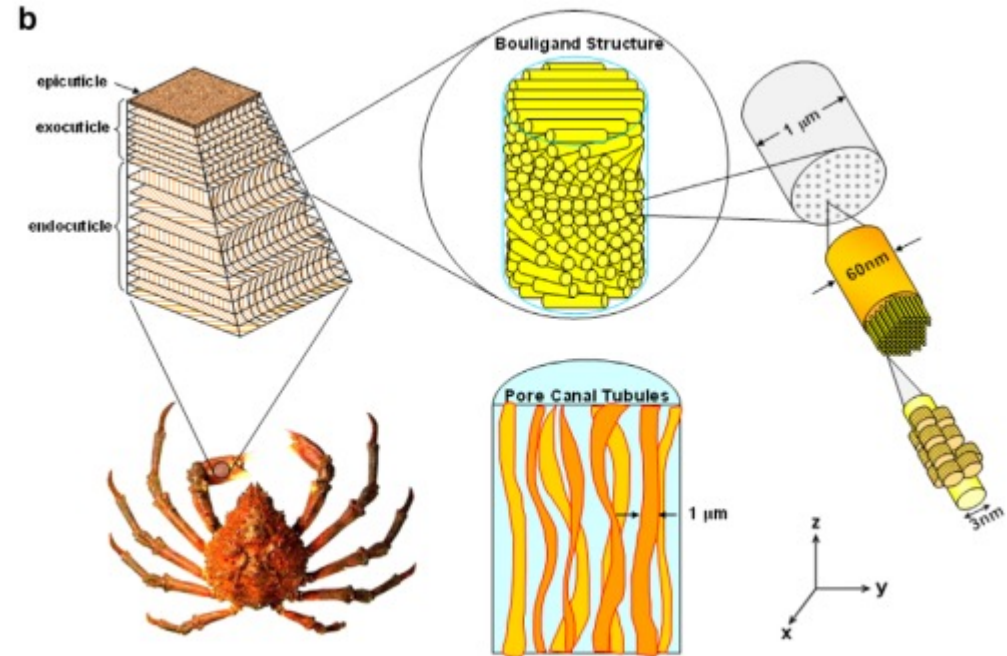
- 3 specimens were bought from a fish market and kept at the aquarium until they were ready to be dinner tested
- Sections cut with coring saws or dissected and laser cut into dogbones
- Indentation samples mounted in epoxy and polished
- Gold sputtered onto fracture surfaces for characterization



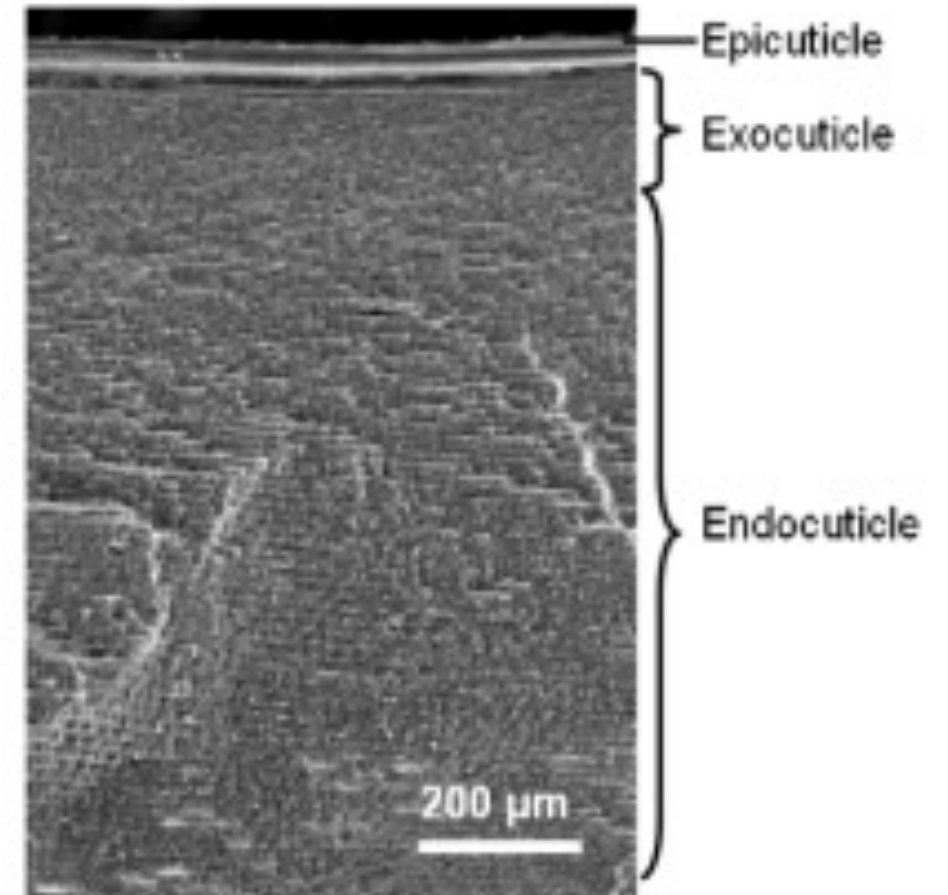
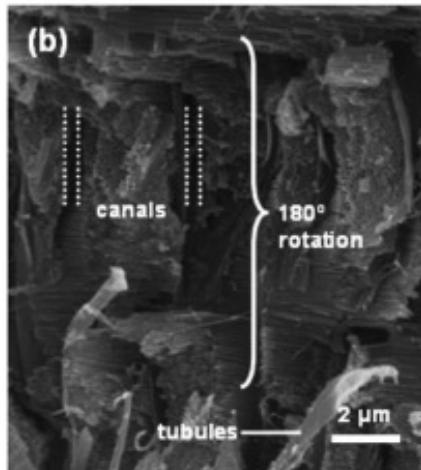
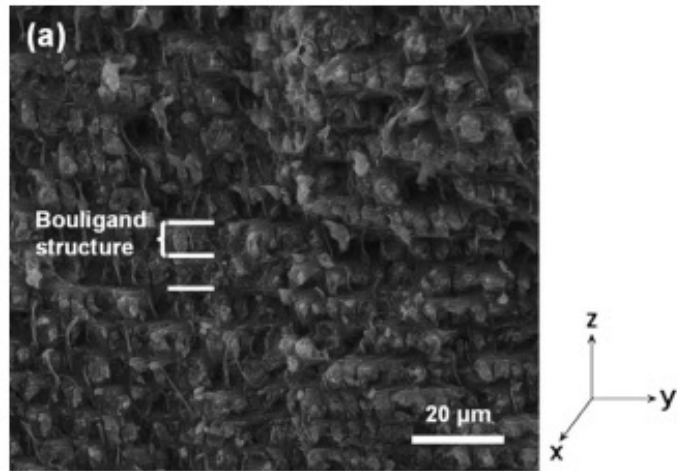


# Exoskeleton Structure

- Hierarchical structure composed of biological composites
- Chitin fibrils are bundled together with proteins and arranged in a helical pattern to form a bouligand structure
- Exocuticle is more densely packed but endocuticle comprises 90% of the volume of the exoskeleton

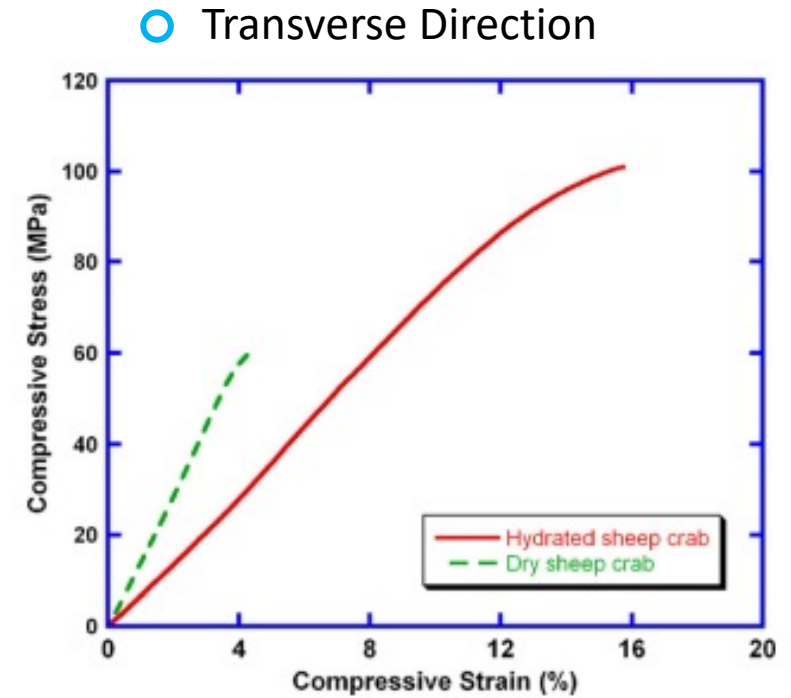
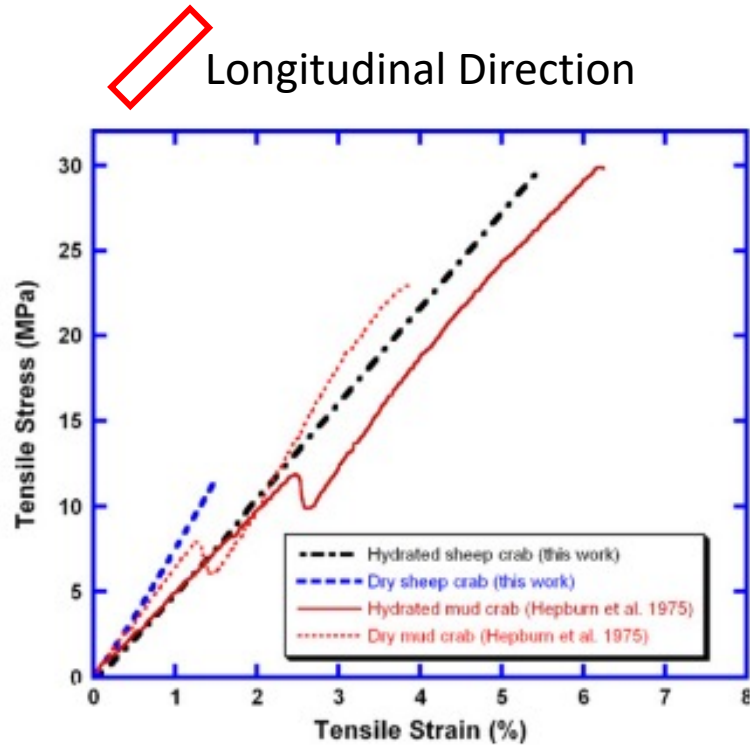


# SEM Images of Exoskeleton Structure



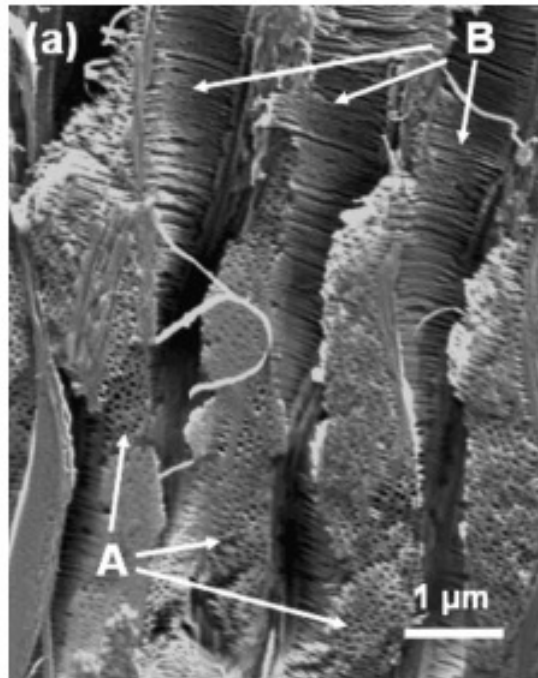


# Wet versus Dry Tensile Tests

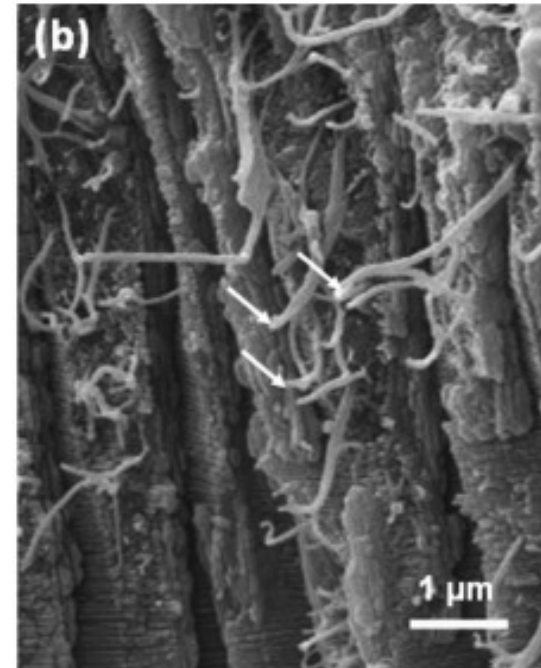


# Fracture Surface of Longitudinal Tensile Tests

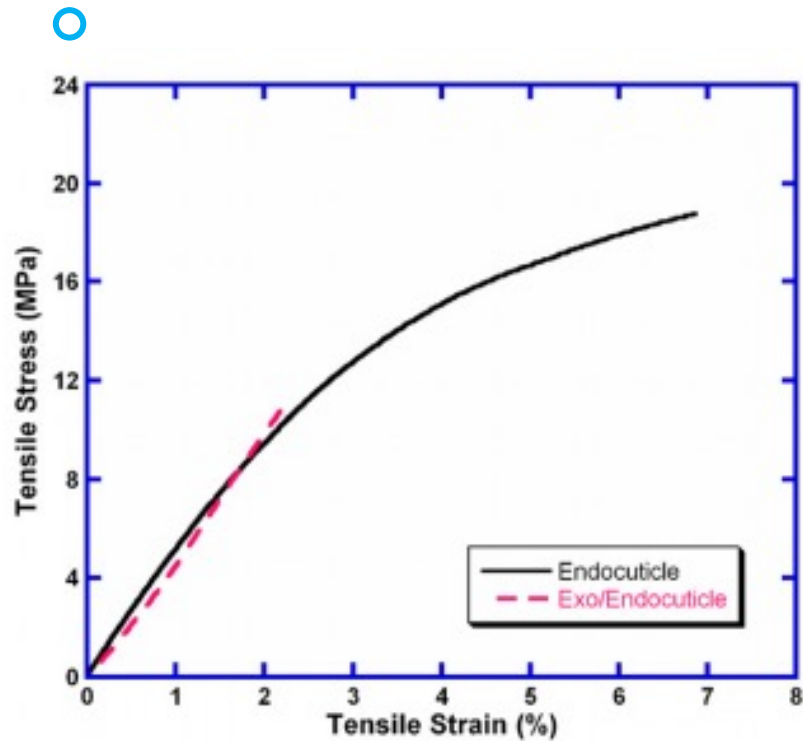
Dry Conditions



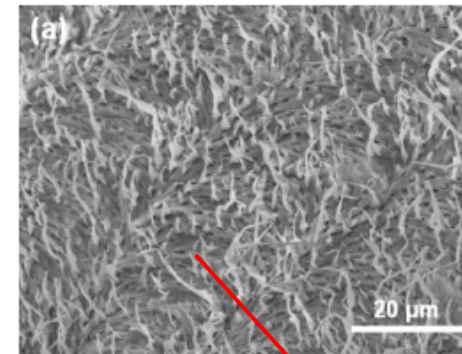
Wet Conditions



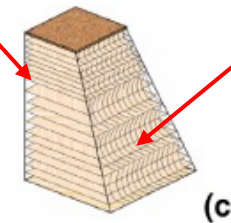
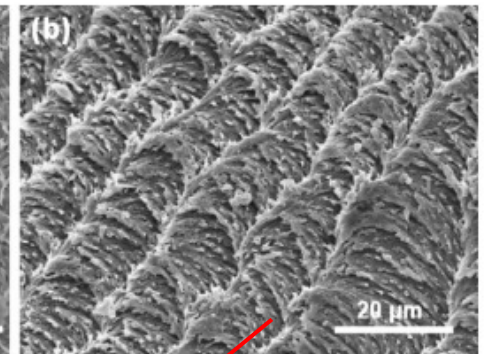
# Transverse Tensile Tests



Fracture between endocuticle and exocuticle



Fracture within the endocuticle





# Indentation and Failure Modes



## Transverse Microindentation

