

Lecture prepared by R. @ Á^ & @ æ

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Coatings Inspired by Natural Systems



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Biomimicry Alberta Workshop, Sunday, Oct. 2, 2016
UofC Biogeoscience Centre, Barrier Lake, Kananaskis, AB



BiomimicryAlberta



materials at the interface

Acknowledgements

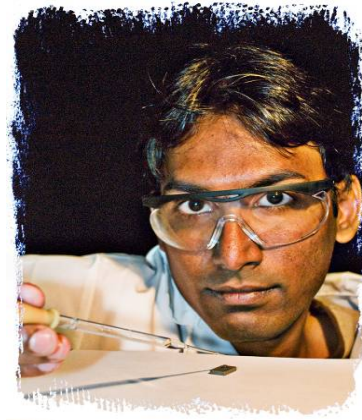
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- HQP:



Y. Chen



M. Glasper

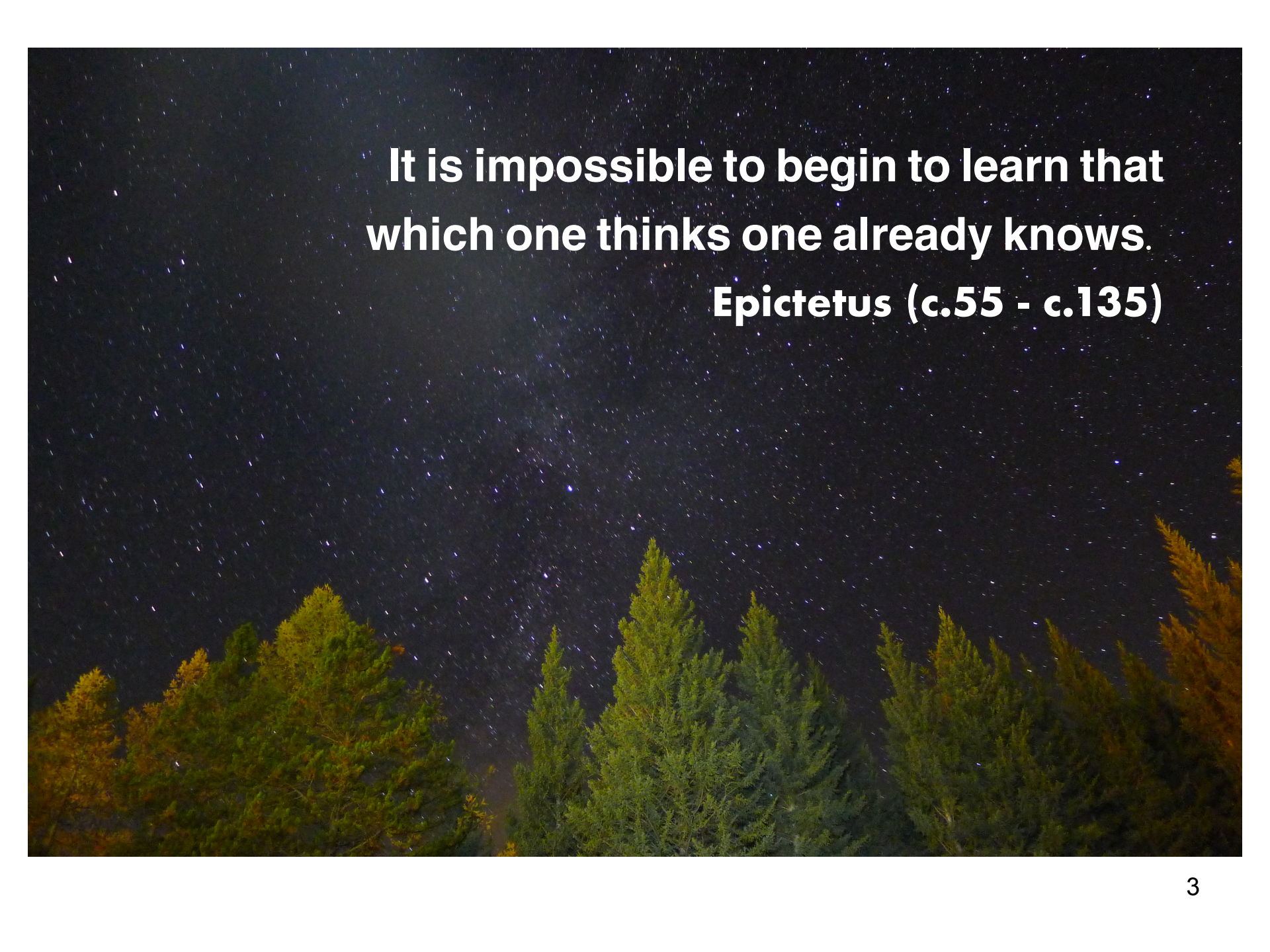


J. Samad



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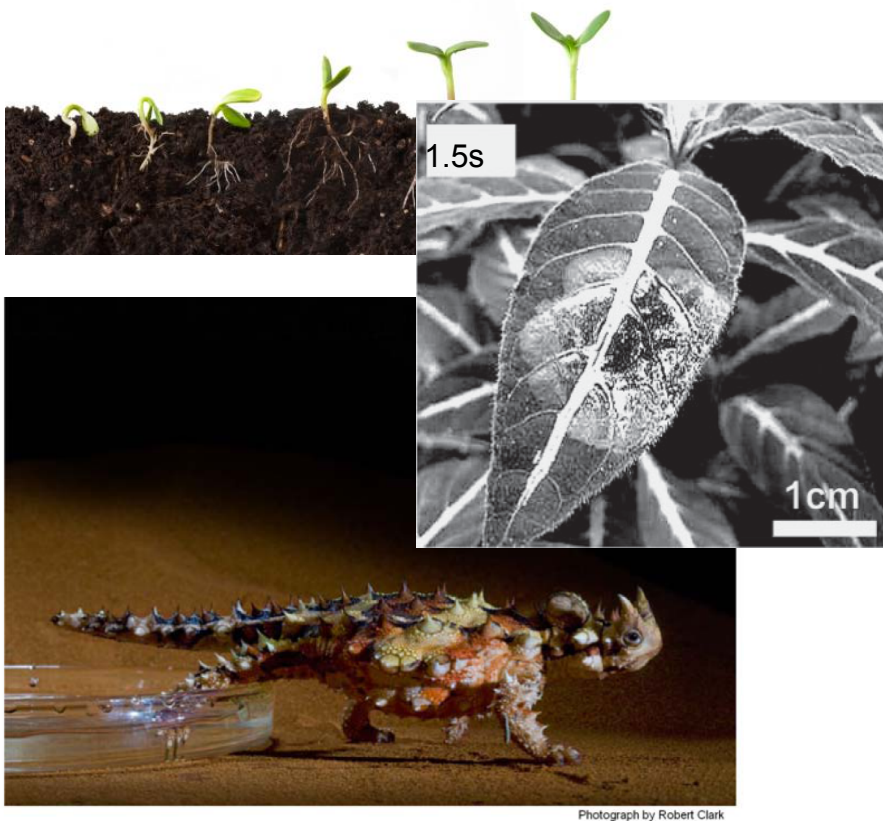
**It is impossible to begin to learn that
which one thinks one already knows.**

Epictetus (c.55 - c.135)



Water-surface interactions

- Hydrophilic



- Hydrophobic



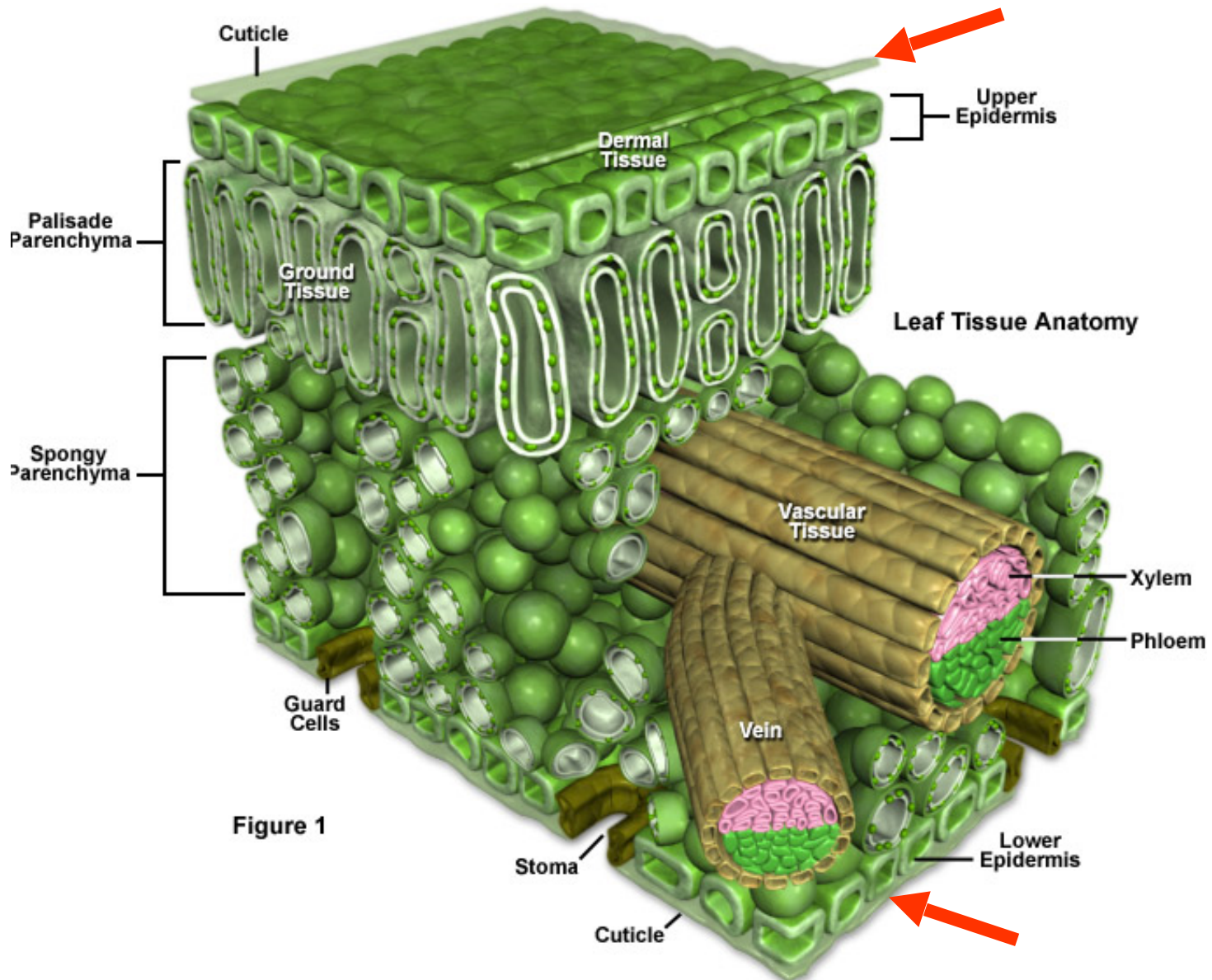
Roots: <http://images.sciencedaily.com/2009/07/090707111705-large.jpg>

Thorny devil lizard: Design by Nature: <http://ngm.nationalgeographic.com/2008/04/biomimetics/clark-photography>

Tropical herb *Ruellia devosianan* superhydrophilic leaf with water drop spreading: Koch *et al.* FUNCT PLANT BIOL, 2009, **36**, 339-350

Aristolochia elegans superhydrophobic leaf with water drops, Japanese beetle, © 2010 J.A. Nychka

Leaf structure



Stratification of the outer part of epidermis cells

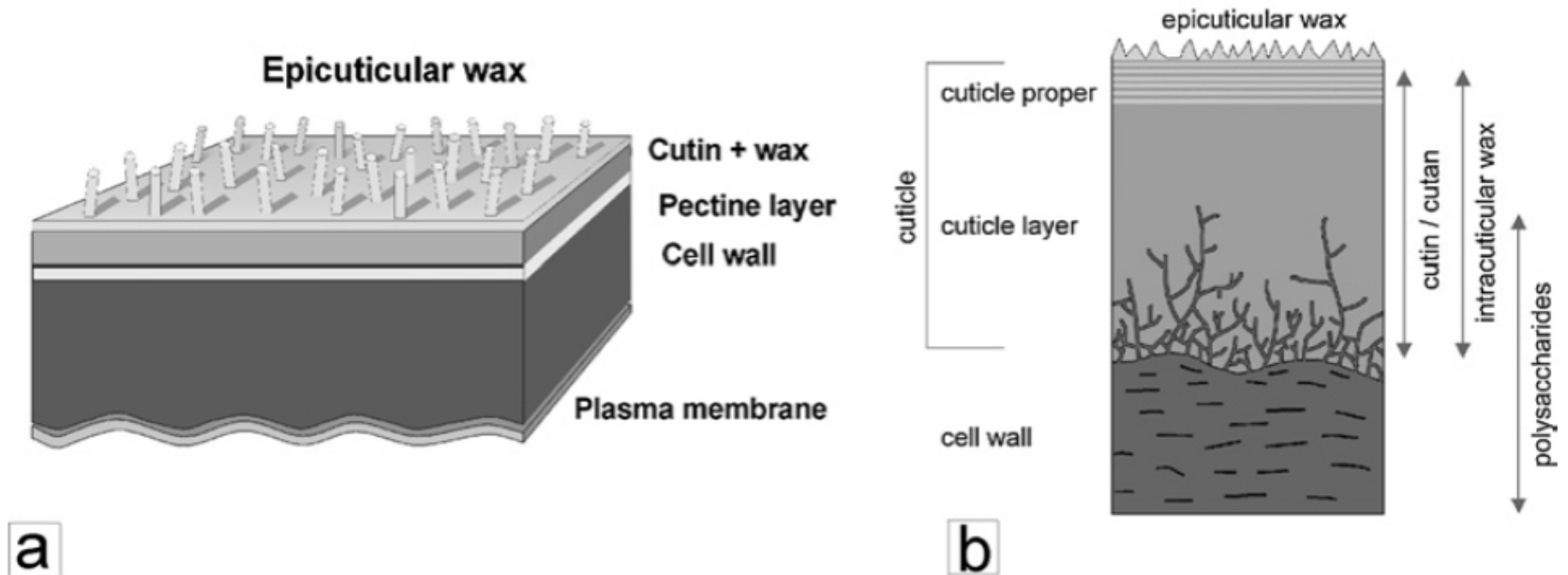
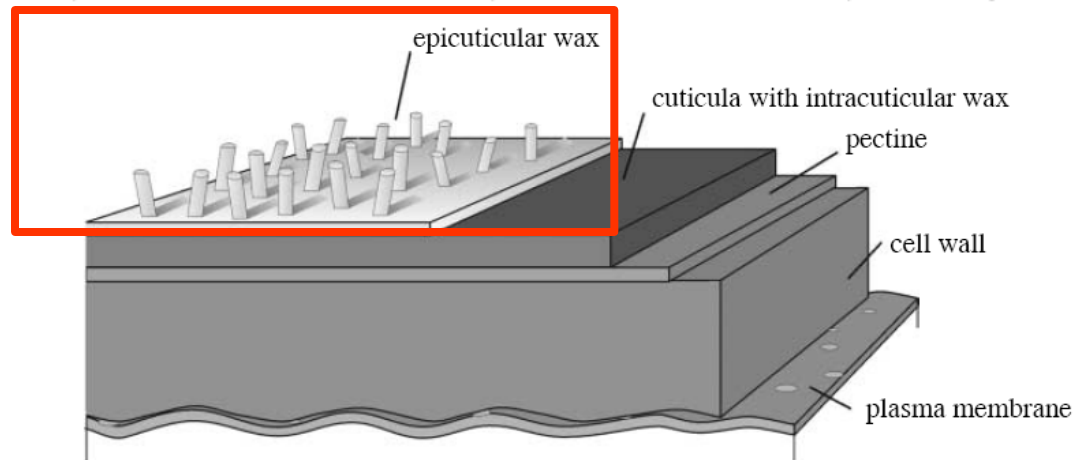
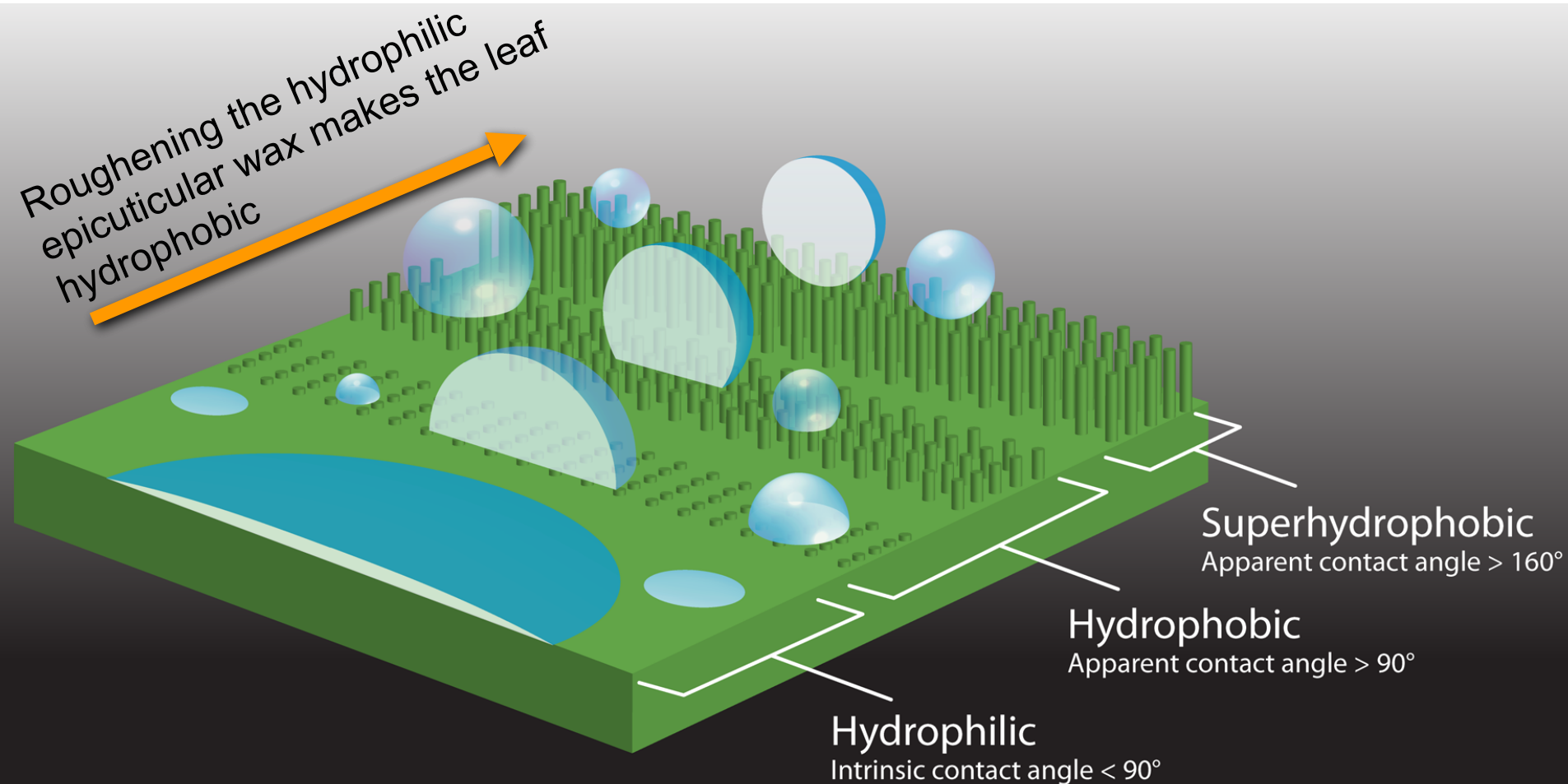


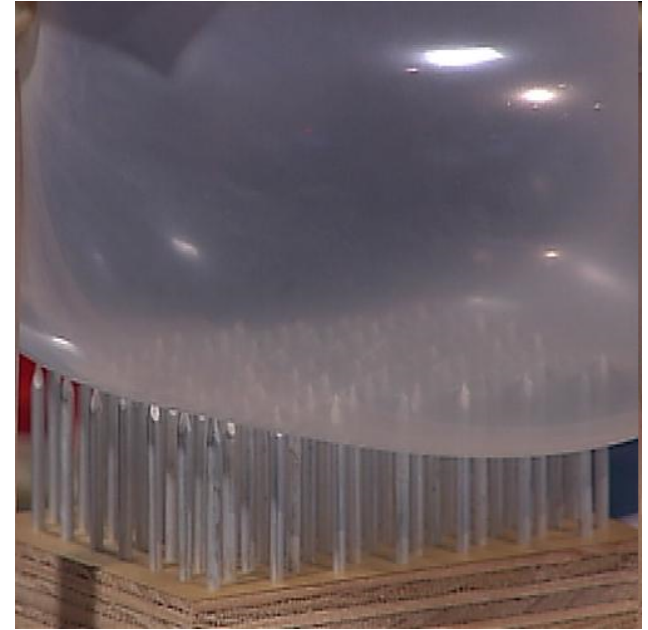
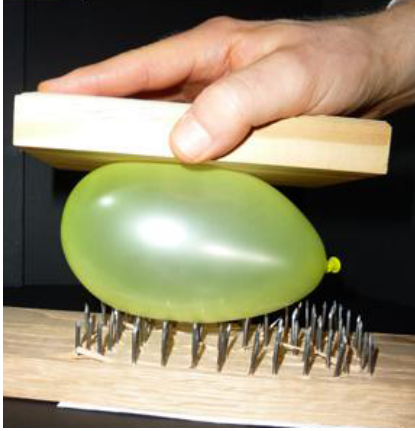
Fig. 2 (a) Shows a simplified model of the stratification of the outermost layers of the plant epidermis cells. The cuticle and its connection to the cell wall is presented in more detail in (b). In this hypothetical scheme of the structural features of the plant cuticle (modified after ref. 28) cellulose fibers and polysaccharides exist in the cuticle layer. Pectin is not visualized as a layer, because evidence for a layered arrangement of pectins exists only for some species.



Leaf Surfaces: Stable Cassie-Baxter States



Bed of nails analogy

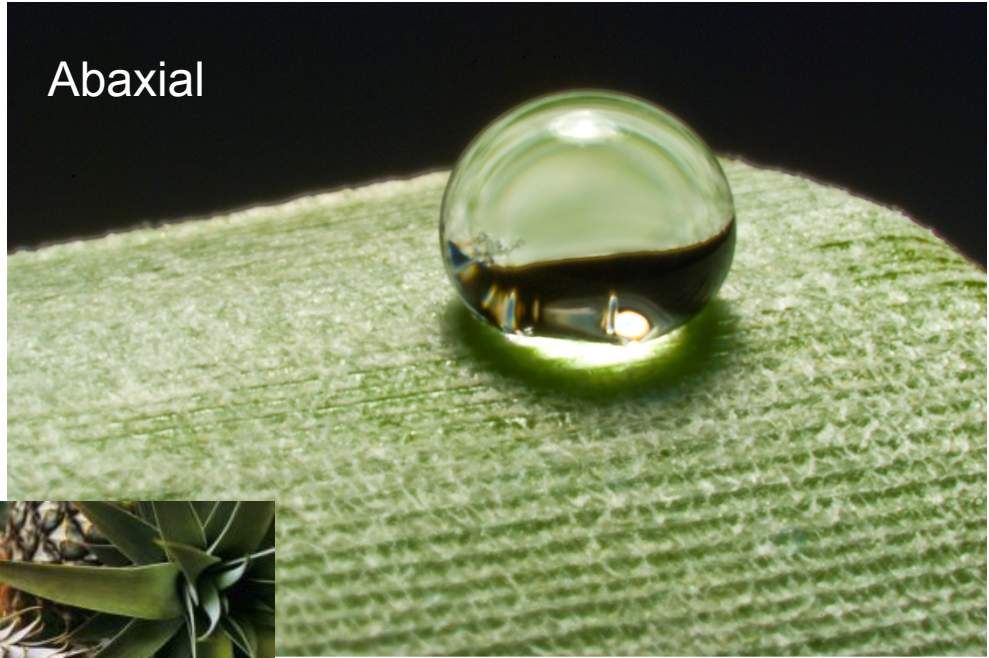


<http://www.flickr.com/photos/judyjowers/4441680685/sizes/o/in/photostream/>

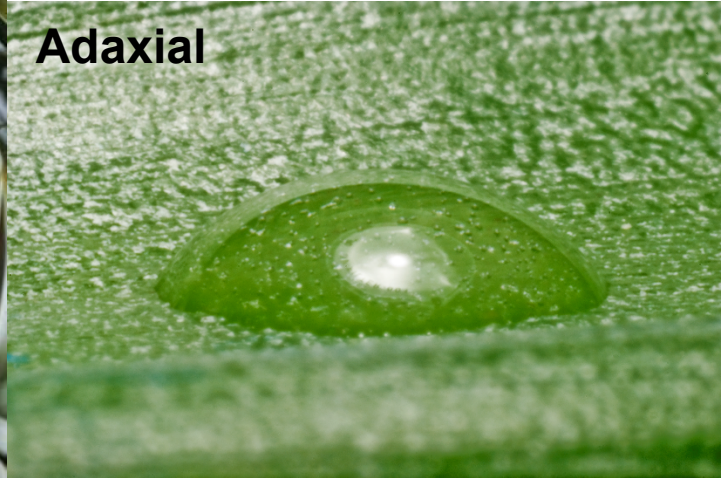
Ananas comosus



Abaxial

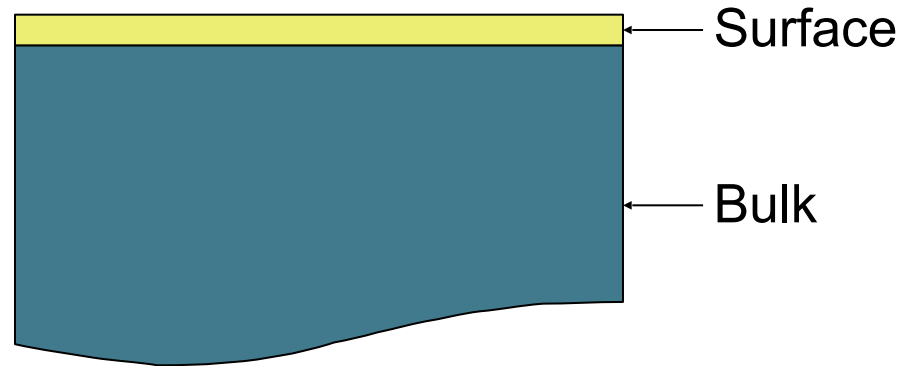


Adaxial



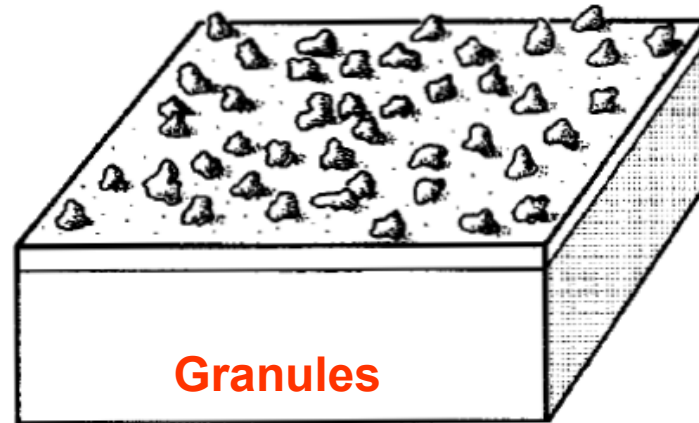
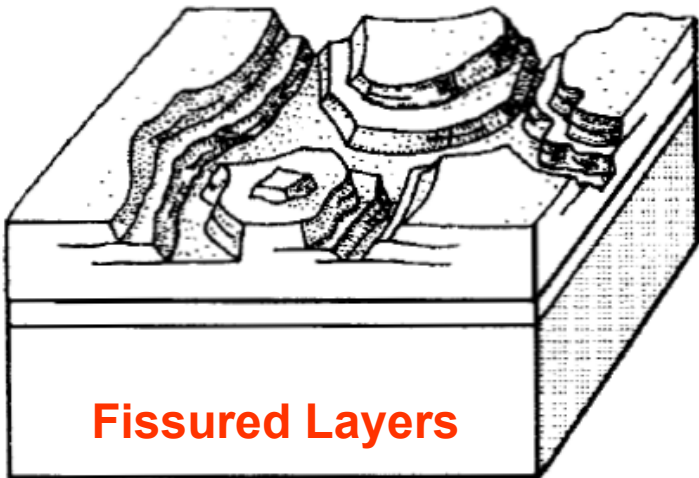
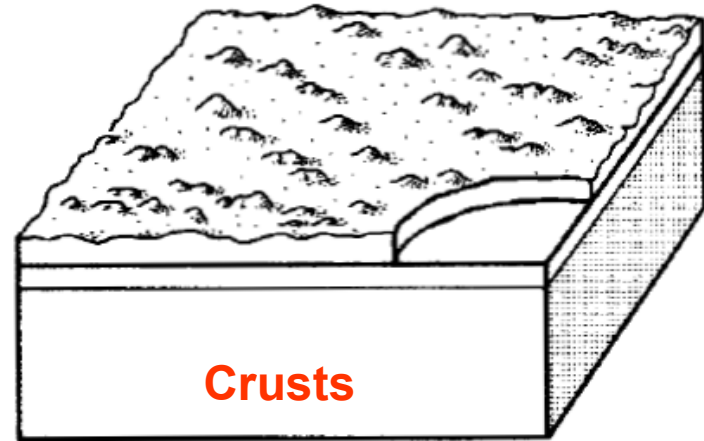
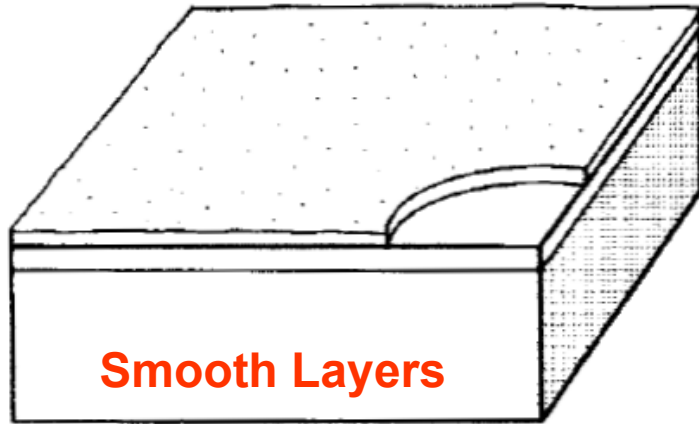
WWW.POTOBANK.RU FC02-8199 FoodCollection
Ripe and unripe pineapples (full-frame)

Surface Engineering Design

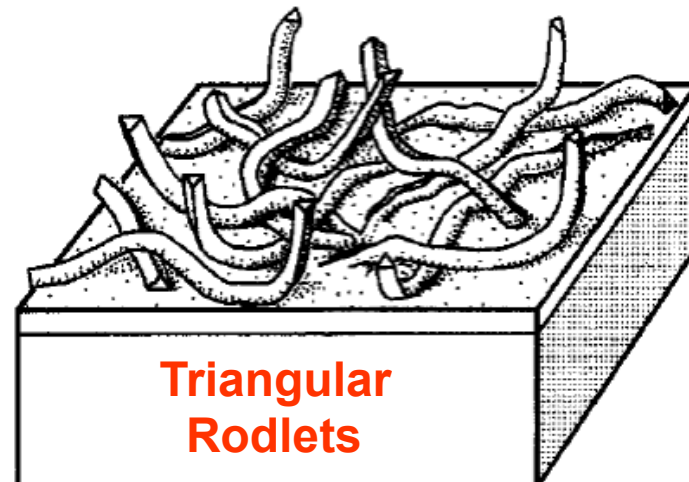
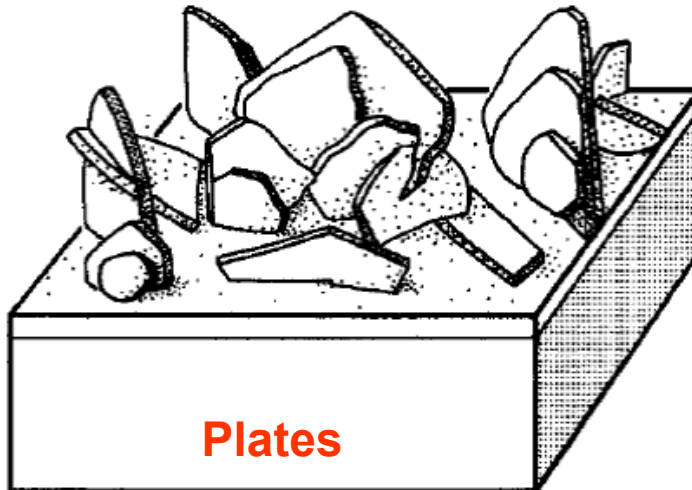
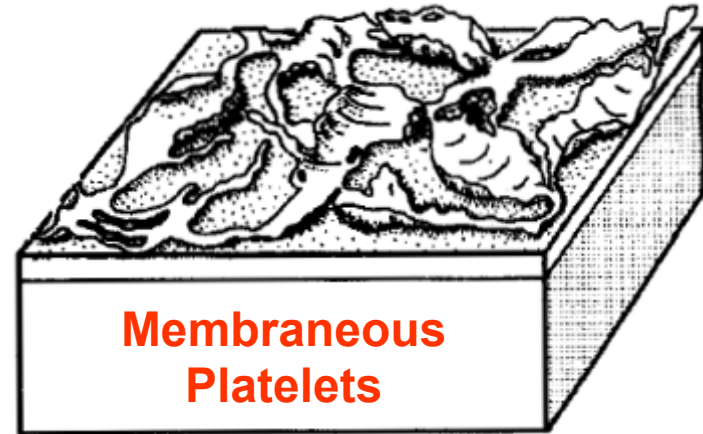
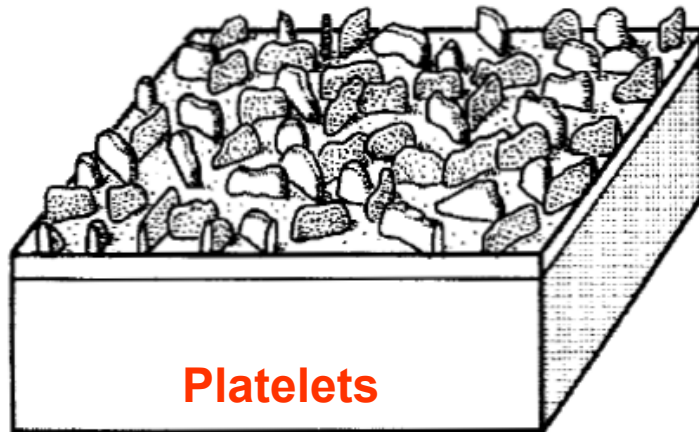


- Bulk properties are not always sufficient...
- Surface engineering is required:
 - Aesthetics, chemical, wear, corrosion, fatigue resistance...
- Alter or coat a surface to achieve desired attributes – the natural world does this!

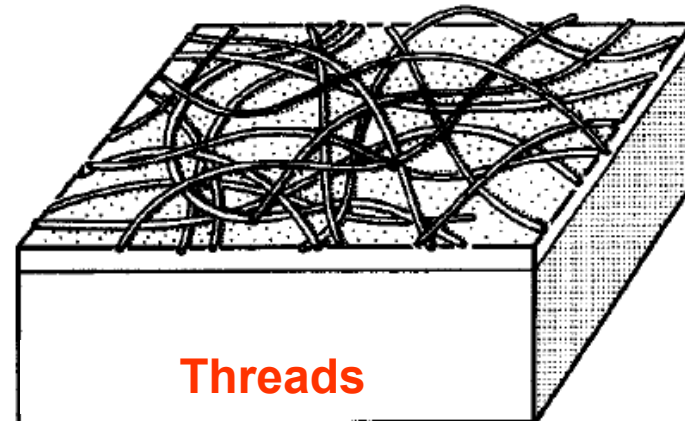
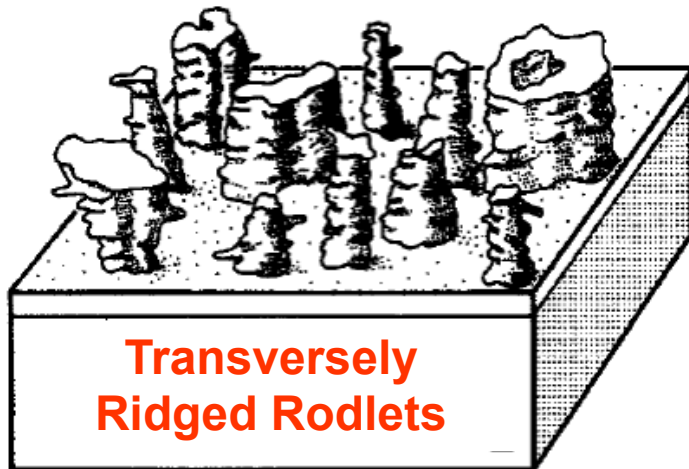
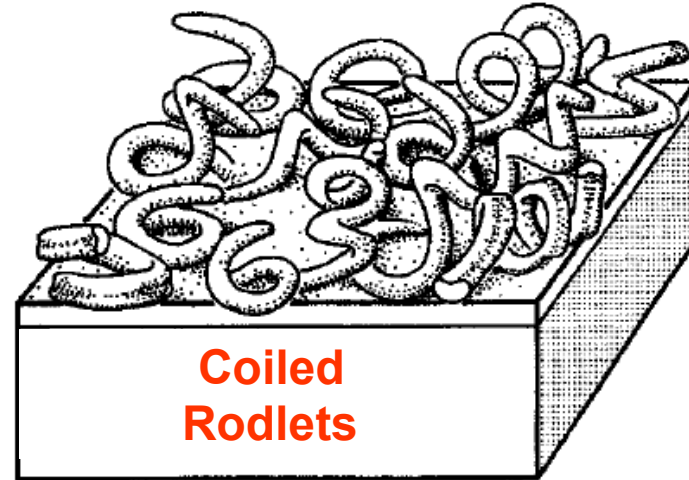
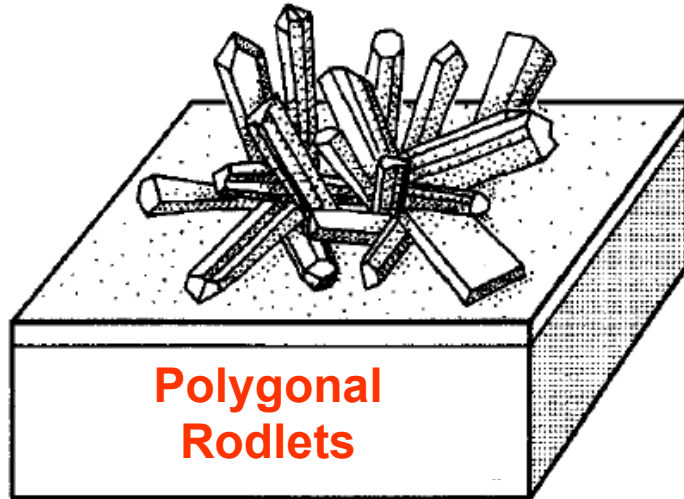
Epicuticular Wax: Diversity of Structure



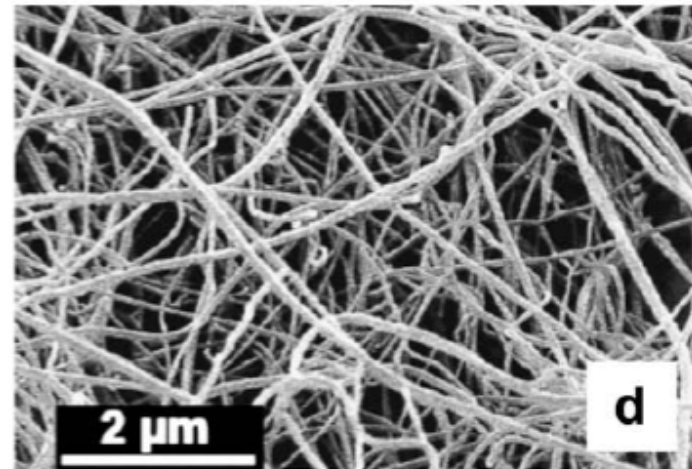
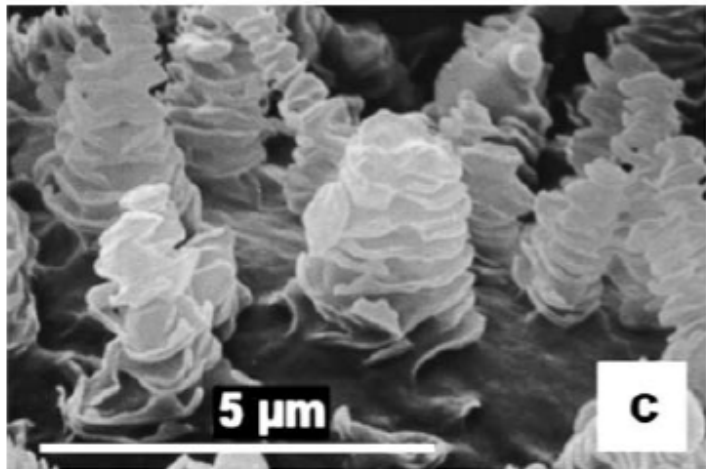
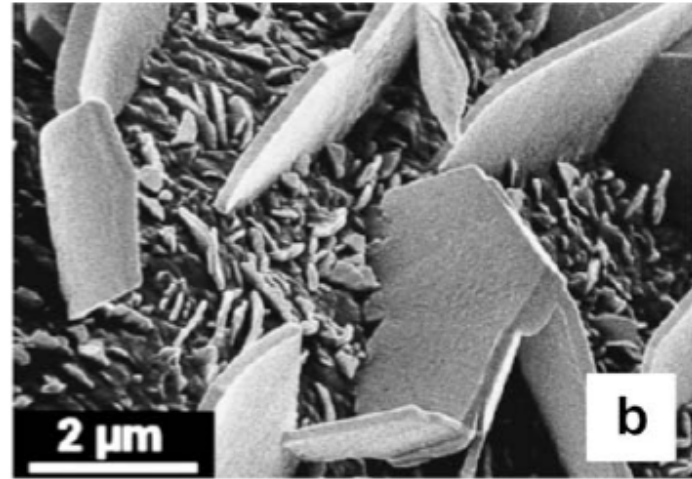
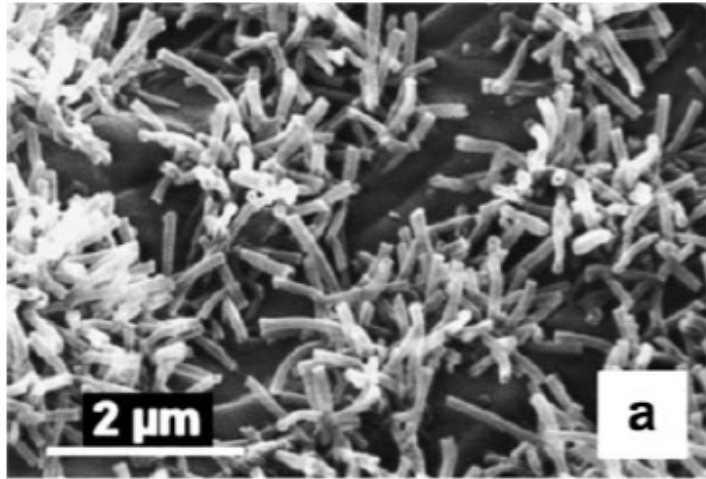
Epicuticular Wax: Diversity of Structure



Epicuticular Wax: Diversity of Structure



Epicuticular Wax: Diversity of Structure



So what?

Now what?

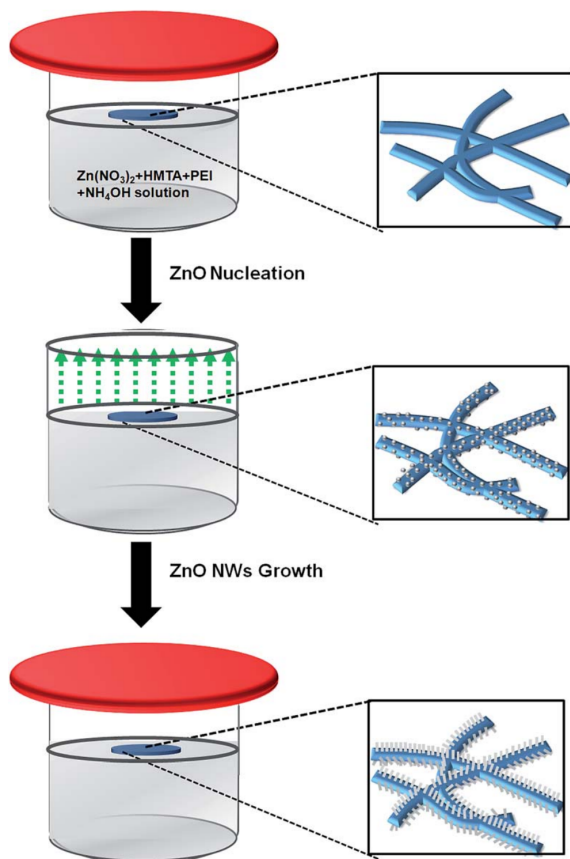


Fig. 1 A schematic illustration of the ZnO NWs growth on filter paper.

Coat filter paper with nanostructures...

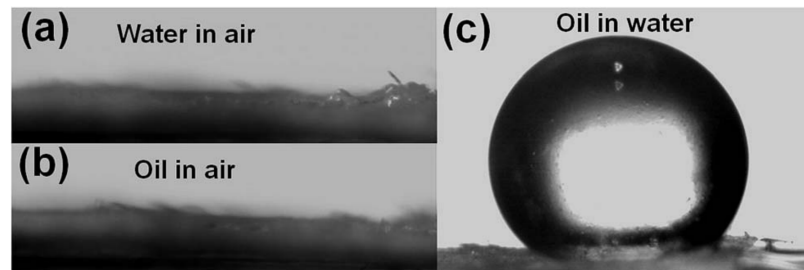
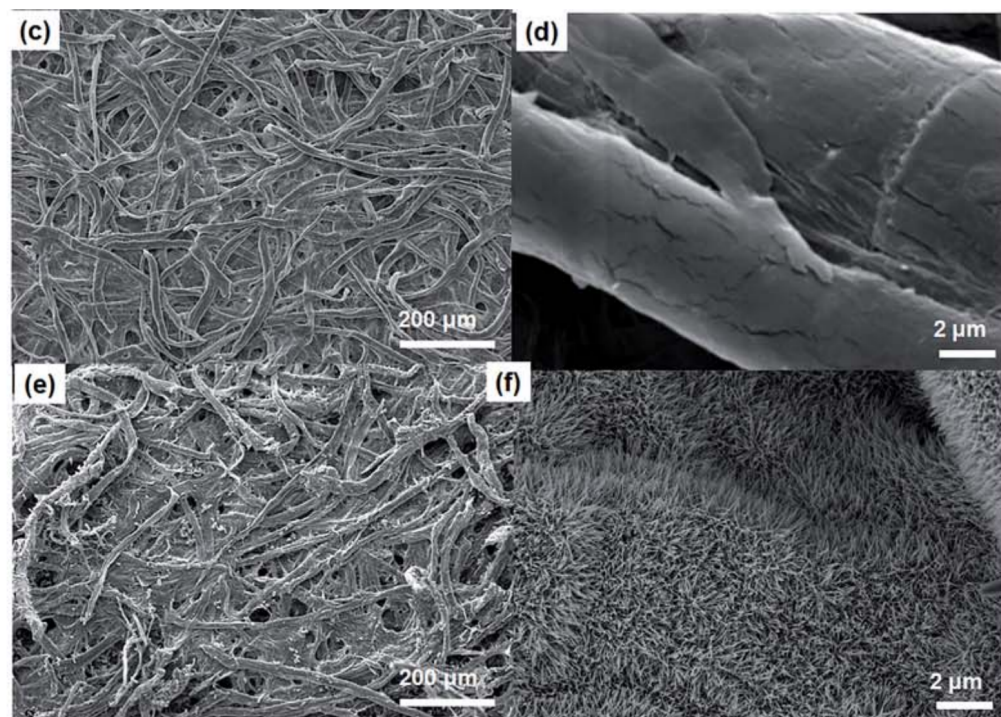


Fig. 3 Wettability of coated filter paper. (a) Photograph of contact angle of water in air (5 μ L drop). (b) Photograph of contact angle of oil in air (5 μ L drop). In both (a) and (b) no visible drops can be seen – the drops have completely wetted the coated filter paper. (c) Photograph of underwater contact angle of oil (5 μ L drop).



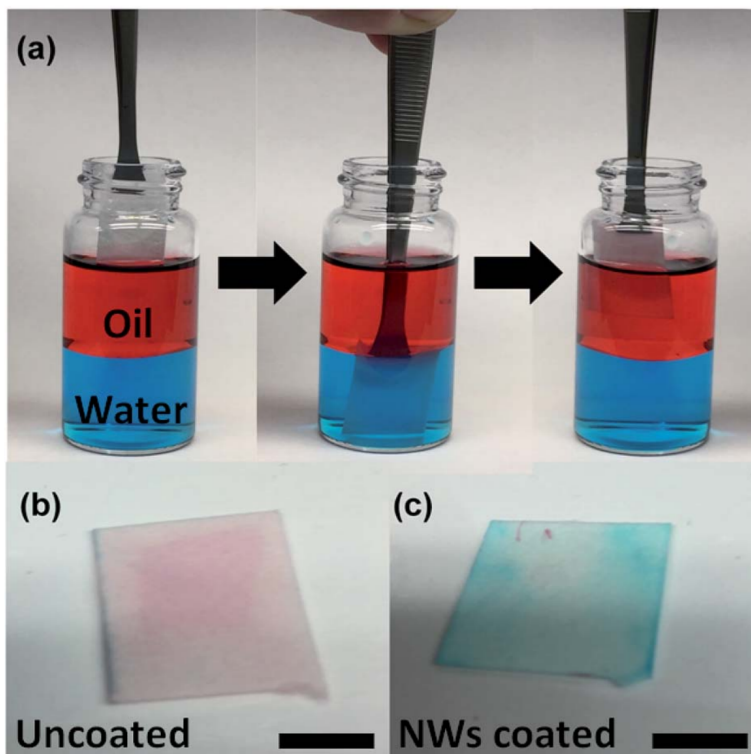


Fig. 4 (a) Demonstration of oil/water selective absorption process. Water was dyed by methylene blue, and oil was dyed by Oil Red O. Optical images of (b) uncoated filter paper after the oil/water absorption – oil was absorbed; (c) ZnO coated filter paper after the oil/water absorption – water was absorbed (scale bar is 1 cm).

Coated filter paper separates oil and water...

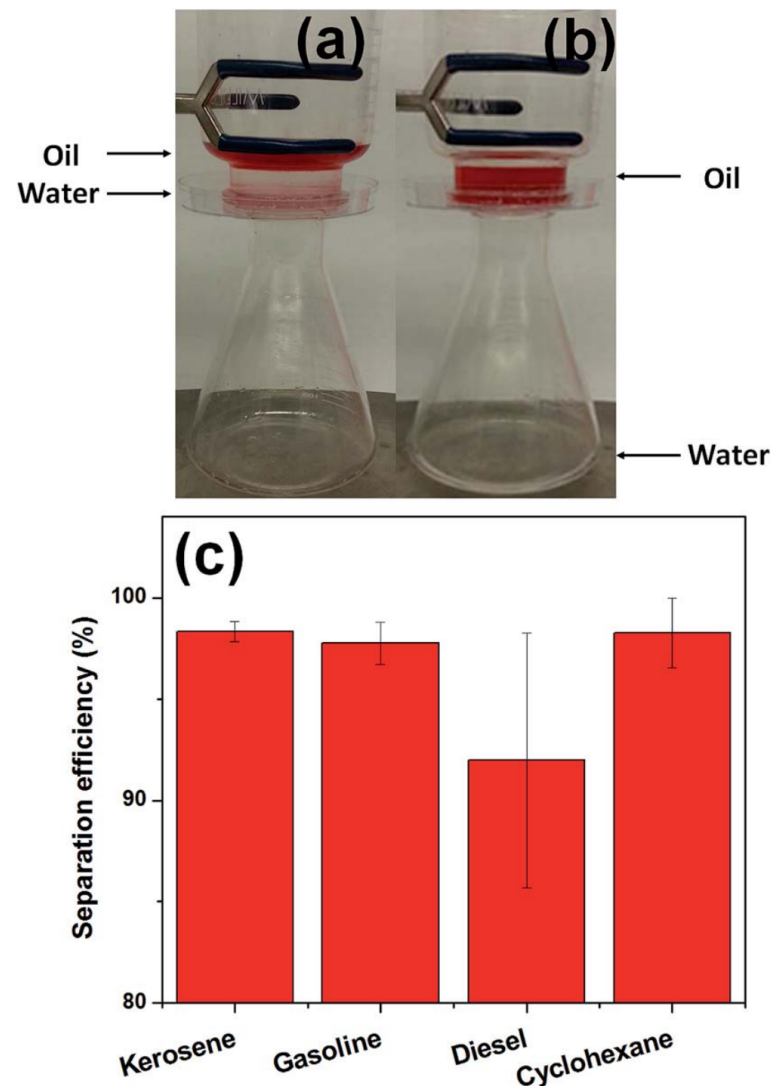
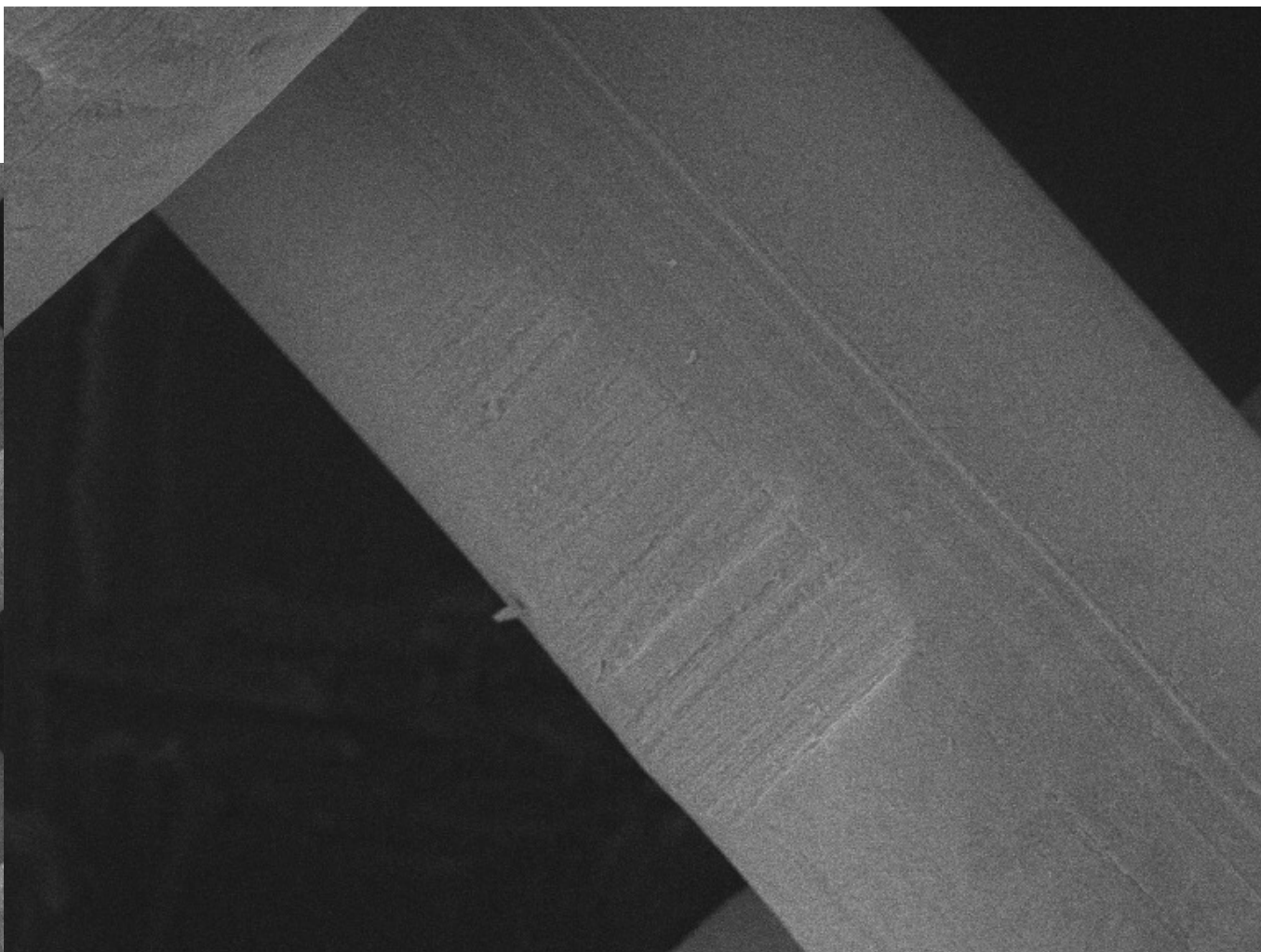
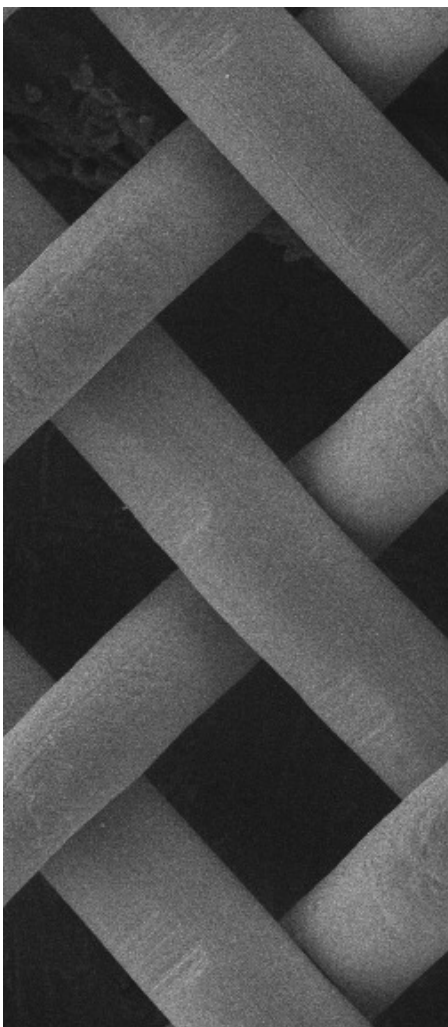


Fig. 5 Photograph of separation test. Digital photo of kerosene (dyed with Oil Red O)/water mixture before (a) and after (b) separation. (c) Separation efficiency of as-prepared filter paper for four different oil/water mixtures.

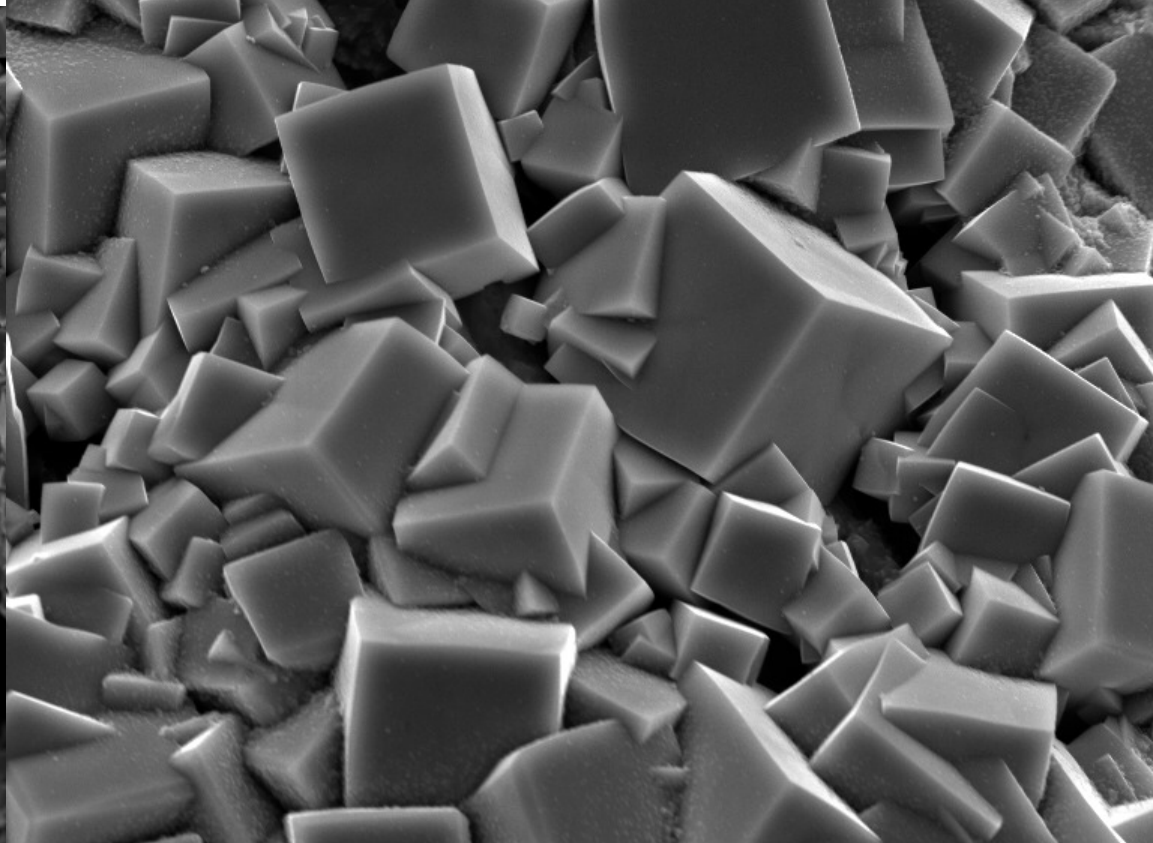
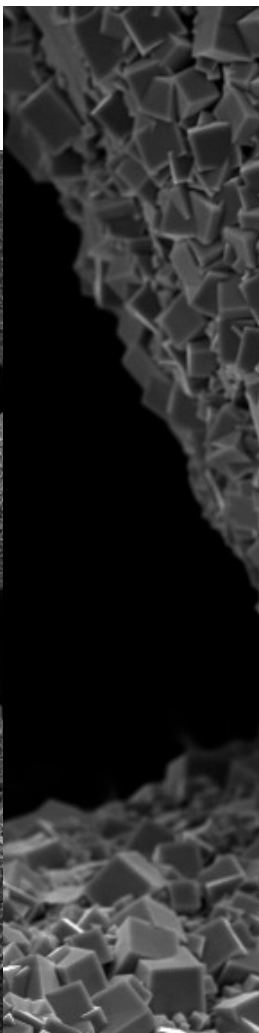
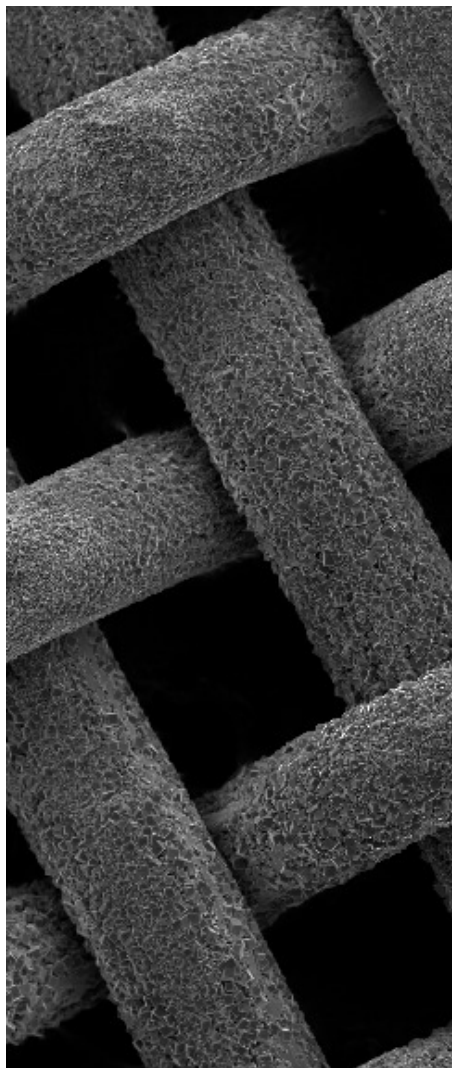
Copper mesh



SEM HV: 20 kV	WD: 7.50 mm	 VEGA3 TESCAN
View field: 217 μm	Det: SE	
SEM MAG: 1.00 kx	Date(m/d/y): 06/18/15	

SEM HV: 20 kV	WD: 7.50 mm	 VEGA3 TESCAN
View field: 1.08 mm	Det: SE	
SEM MAG: 200 x	Date(m/d/y): 06/18/15	

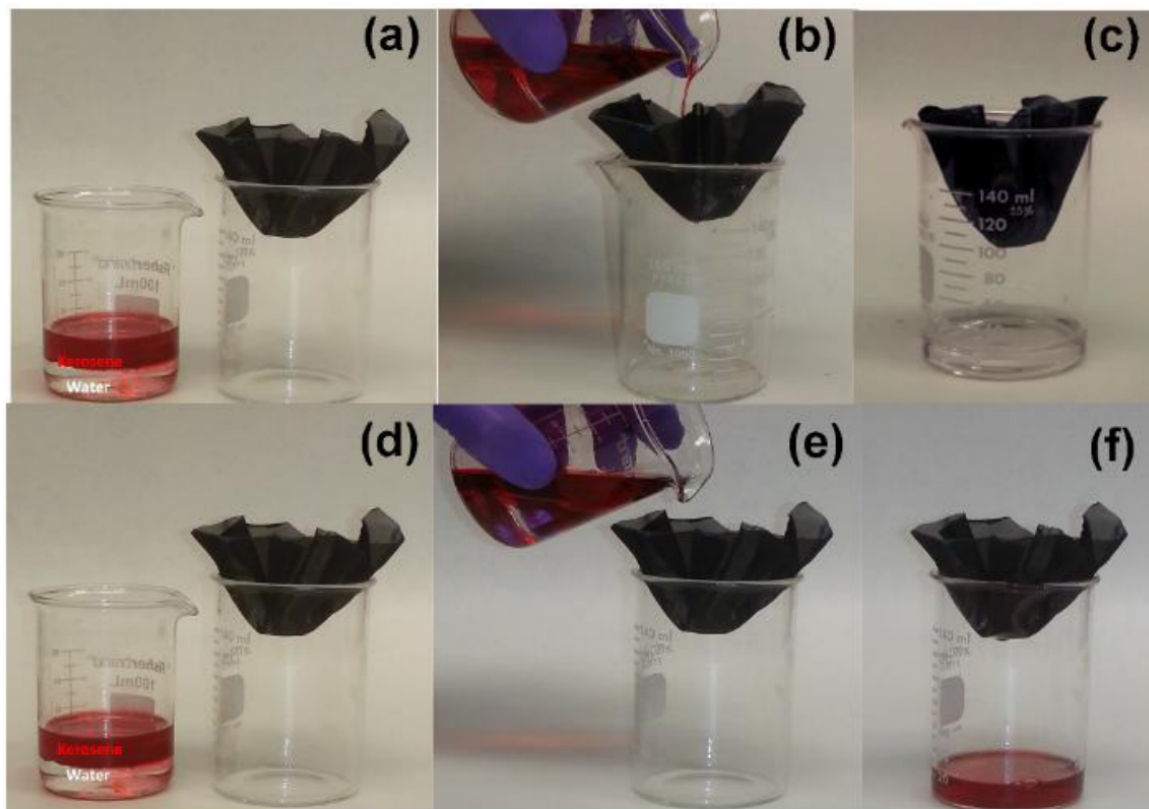
UV oxidized Copper mesh



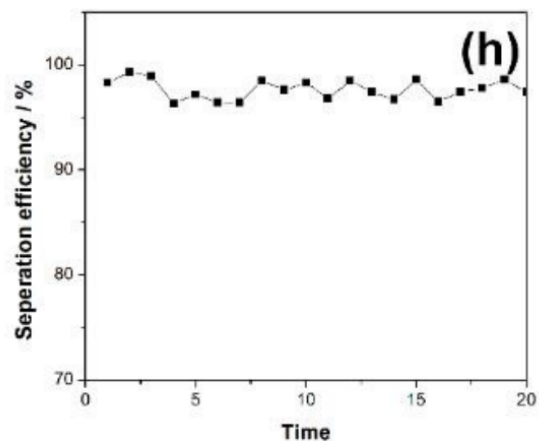
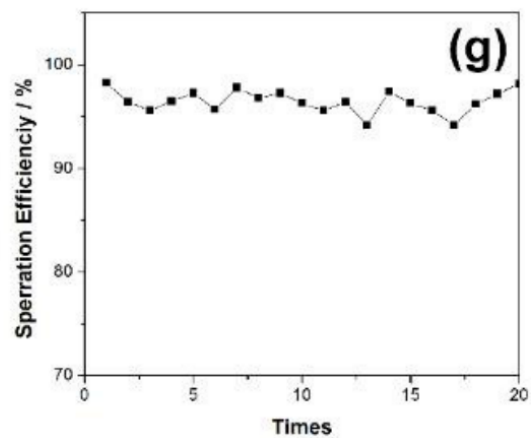
SEM HV: 20 kV	WD: 5.20 mm		VEGA3 TESCAN
View field: 43.3 μm	Det: SE	10 μm	
SEM MAG: 5.00 kx	Date(m/d/y): 02/24/15		

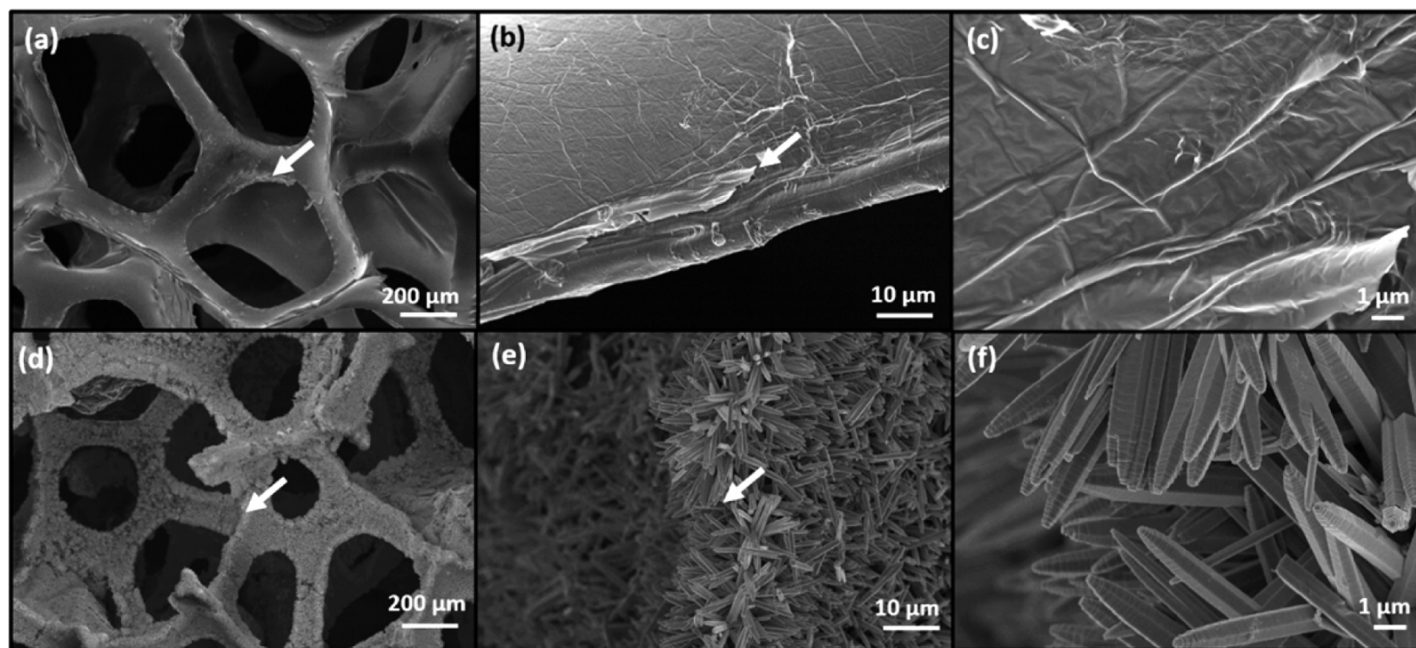
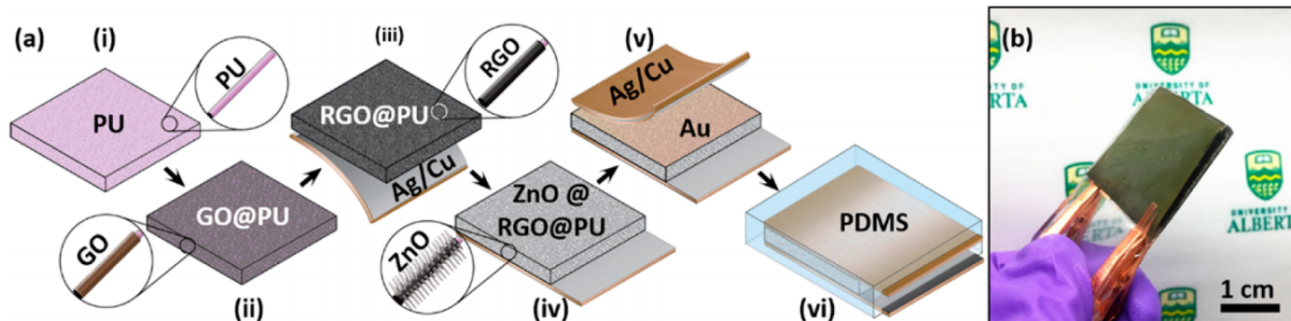
SEM HV: 20 kV	WD: 5.17 mm		VEGA3 TESCAN
View field: 217 μm	Det: SE	50 μm	
SEM MAG: 1.00 kx	Date(m/d/y): 02/24/15		

SEM HV: 20 kV	WD: 5.17 mm		VEGA3 TESCAN
View field: 1.08 mm	Det: SE	200 μm	
SEM MAG: 200 x	Date(m/d/y): 02/24/15		



Coated copper mesh can be tuned to separate oil from water, or water from oil!





Sponge-Templated Macroporous Graphene Network for Piezoelectric ZnO Nanogenerator

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Summary

- Plants, although diverse, have evolved to very few surface designs
- Inherently hydrophilic materials can be superhydrophobic or superhydrophilic when the surface is sculptured on many levels
- Nanotechnology is ever present in leaf waxes – from their assembly to structure
- Biomimicry of surfaces (self-assembly and structure) is possible through coatings - to do all sorts of things!



