

# Mussel-Inspired Adhesives

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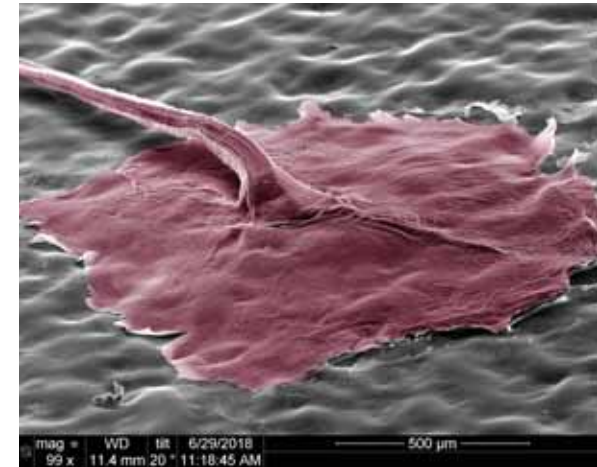
## Biomimetic

... the emulation of the models, systems, and elements of nature for the purpose of solving complex human problems

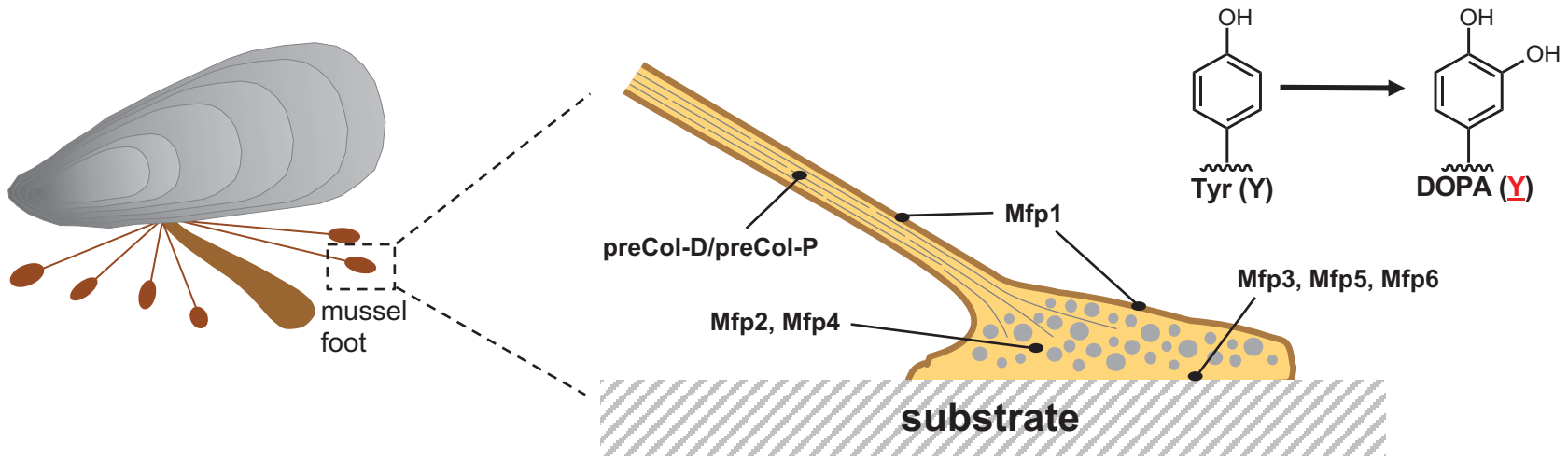
## Bioinspired

...the development of novel materials, devices, and structures inspired by solutions found in biological systems and biological evolution and refinement which has occurred over millions of years

# Inspiration for Novel Materials: The Mussel Byssus



# Mussel Byssal Proteins and DOPA



(identification of proteins by Waite and coworkers, 1980-present)

## Mfp5

(27% DOPA)

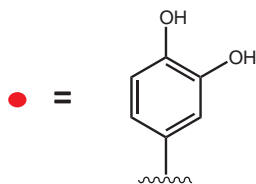
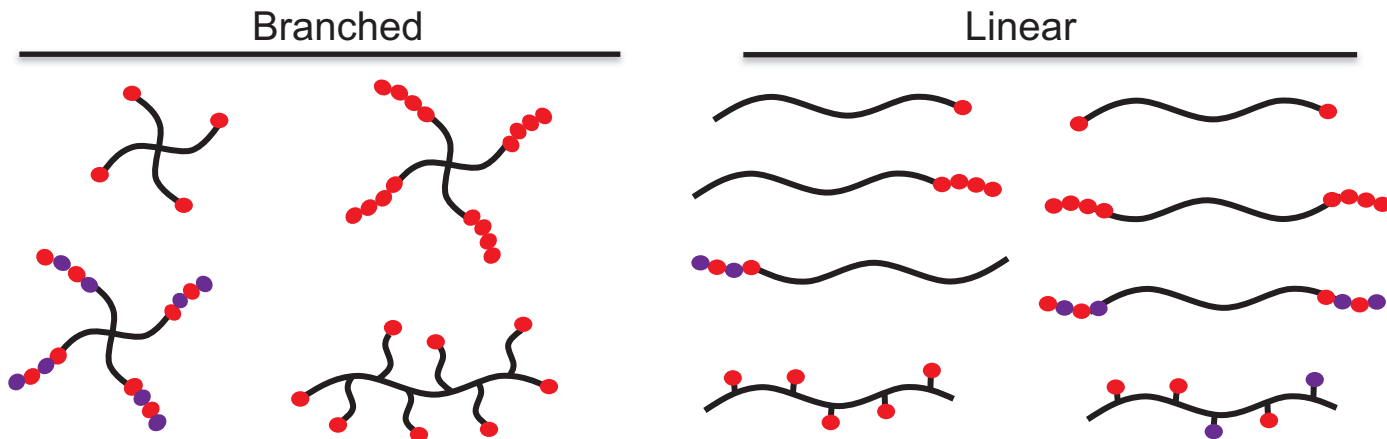
1 SSEEYKGGYYPGNYHYHSGGSYHG  
 26 SGYHGGYKGKYYGKAKKYYYKYKNS  
 51 GKYKYLKKARKYHRKGYKYYGGSS

## Mfp3

(21% DOPA)

1 ADYYGPNYGPPRRYGGGNYNRYNRY  
 26 GRRYGGYKGWNNGWNRGRRGKYW

# Mussel-Inspired Adhesives



• = another amino acid

1. Basic Research
2. Medical Adhesives
3. Consumer Adhesives

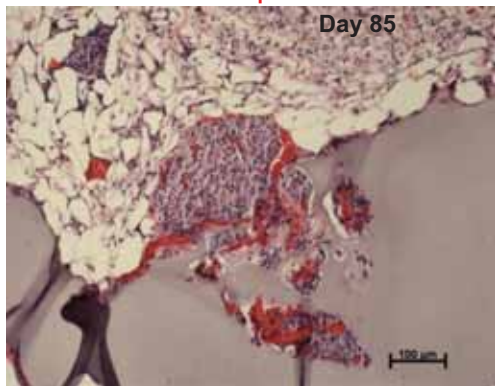
# Studies of Jellyfish Locomotion



With Jenna Nawroth and John Dabiri, Caltech (unpublished)

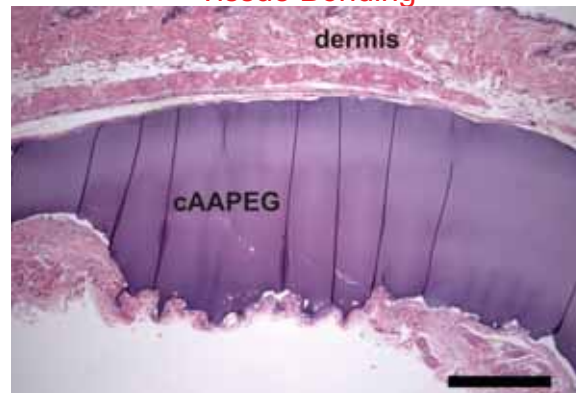
# Medical Applications of Mussel-Inspired Adhesives

## Islet Transplantation



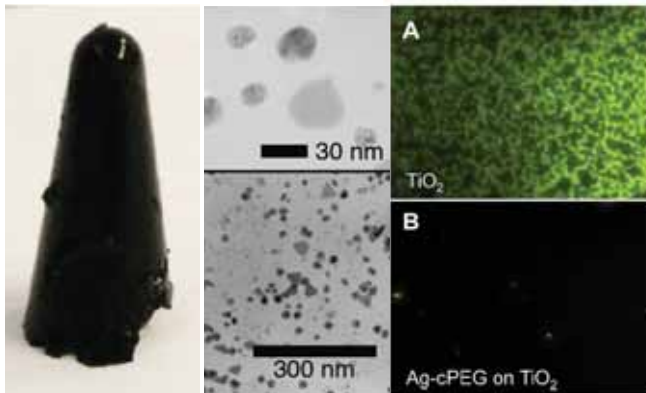
*Biomaterials*, 2010.

## Tissue Bonding



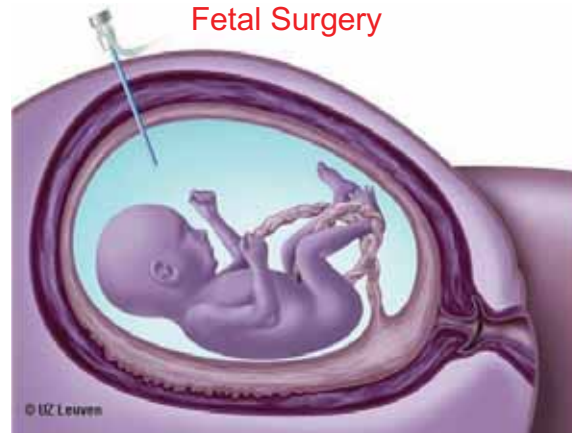
*Biomacromolecules*, 2011.

## Antibacterial Hydrogels



*Biomaterials*, 2012.

## Fetal Surgery

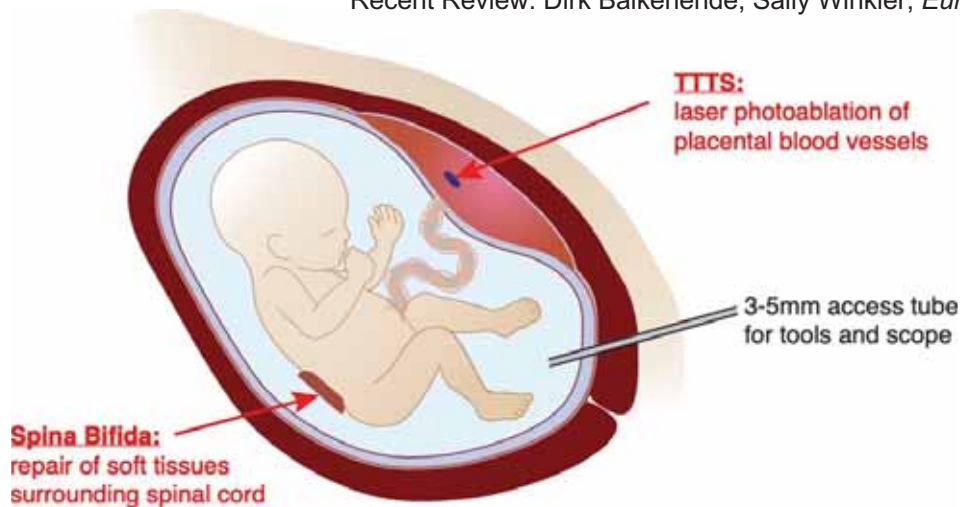


*Am. J. Obst. Gynec.*, 2010; *Prenatal Diagnosis*, 2011.



# Fetal Surgery

Recent Review: Dirk Balkenende, Sally Winkler, *European Polymer Journal*, 2019.



Dr. Michael Harrison (UCSF)

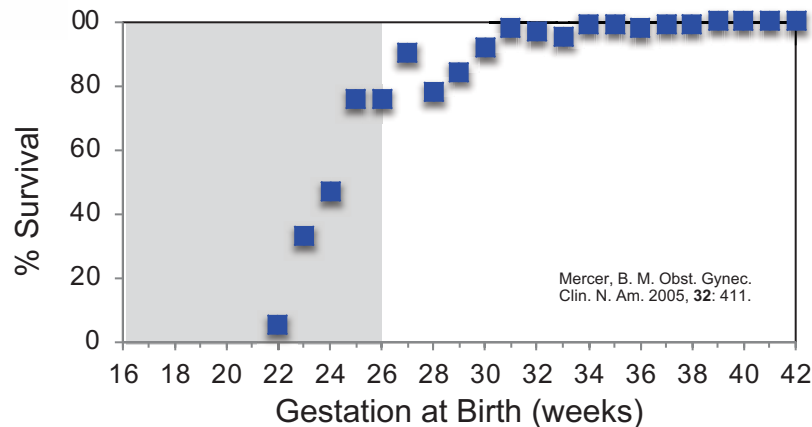


Photo by K. Raddatz/SF Chronicle (5/4/05)

## Post-Surgical Complications:

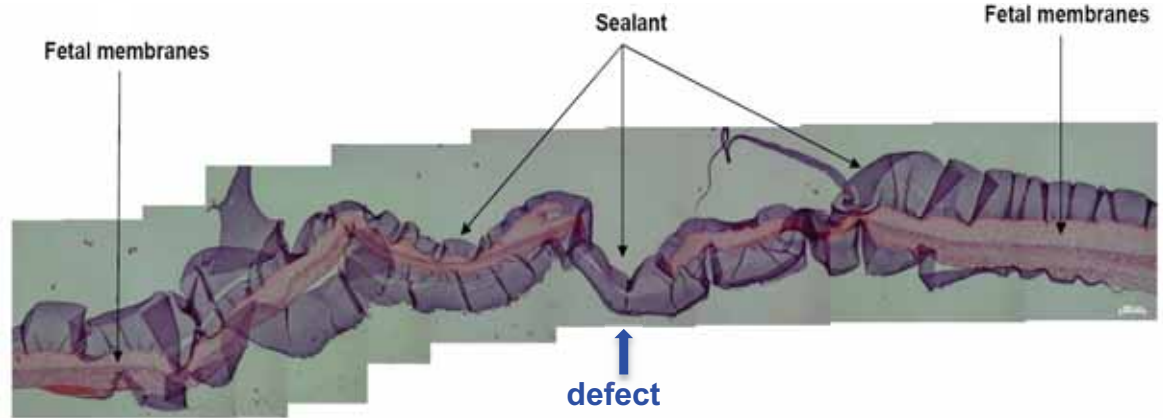
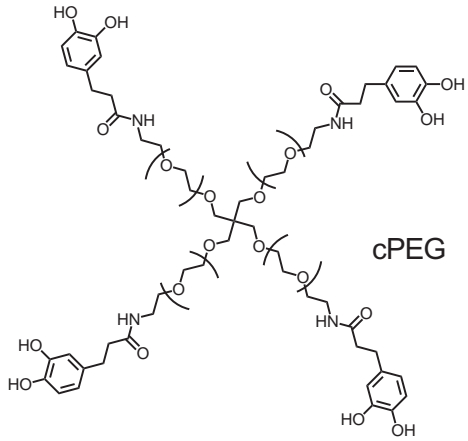
- fetal membranes do not heal, difficult to suture, no approved adhesives
- high risk of premature labor due to premature rupture of membranes (PROM)
- “Achilles Heal” of Fetoscopy<sup>1</sup>

1) Deprest et al., *Lancet*, 1996





# Catechol Polymer for Fetal Membrane Sealing

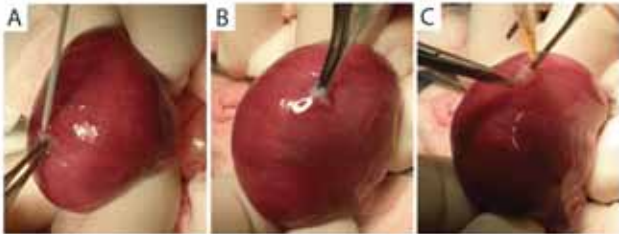


(Messersmith Group w/ A. Zisch Uni. Hosp. Zurich: Am. J. Obst. Gynec., 2010)

Burst Test Results: 120 mm Hg (typical intrauterine pressure <10 mm Hg)

## In-Vivo Study in Rabbits

(7 day gestation)

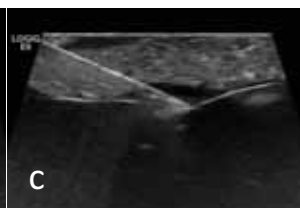
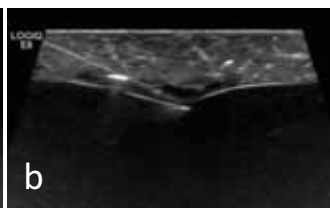
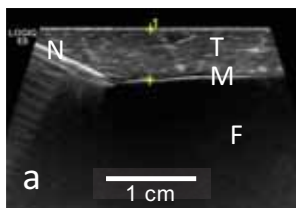
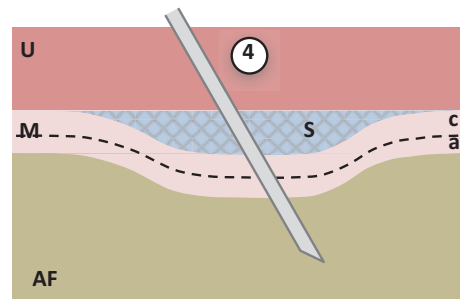
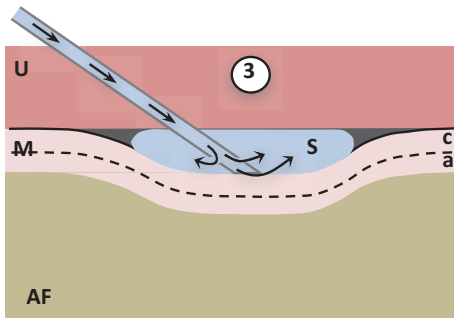
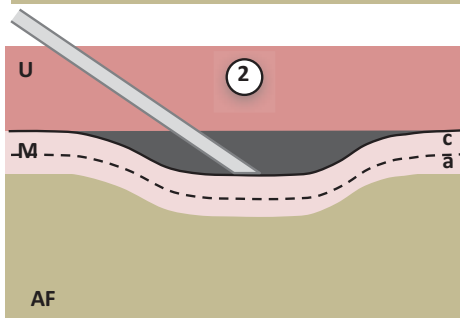
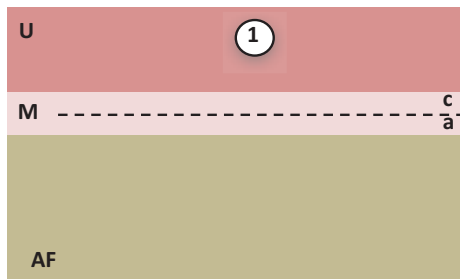


	Control	MG	MG+DAM	FG+DAM
Alive	4	6	8	6
Dead	7	4	2	9
Survival Rate	36%	60%	80%	40%
Leaky sac	75%	33%	25%	0%

(DAM = decellularized amnion scaffold)

# In Progress: Fetal Membrane Pre-Sealing

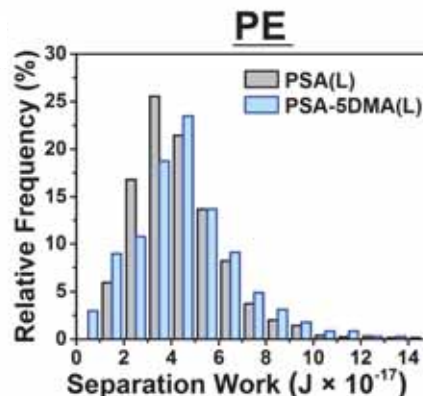
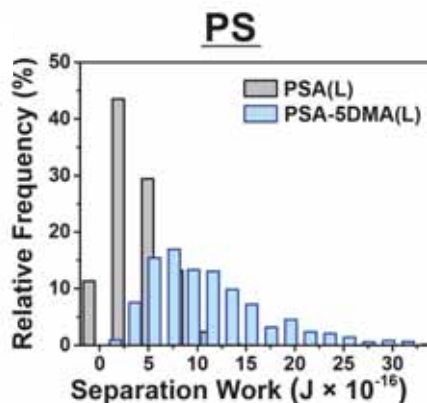
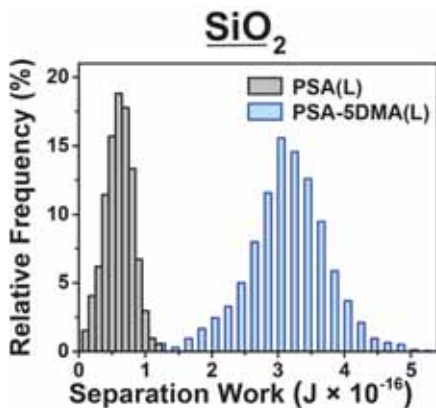
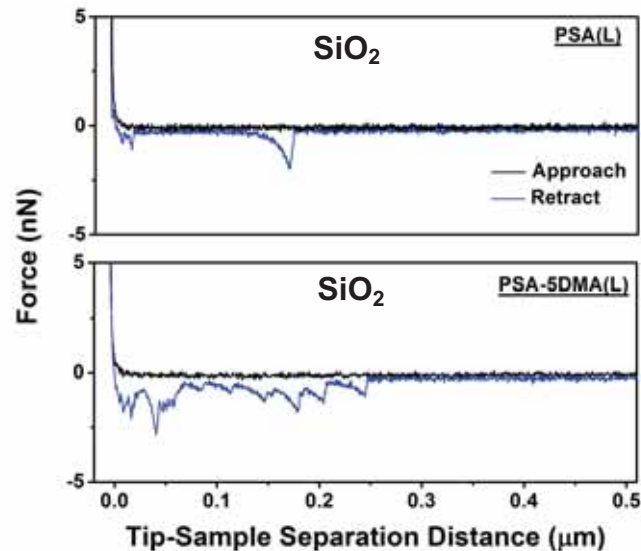
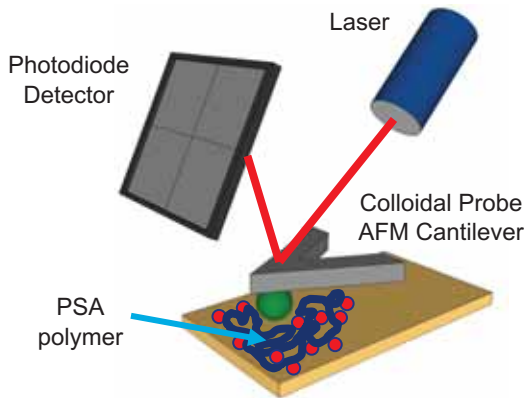
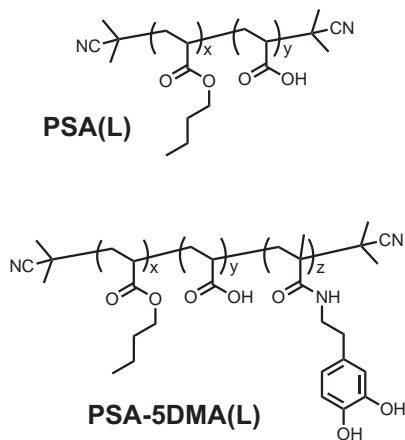
with Mike Harrison (UCSF)





# Mussel-Inspired PSA: Colloidal Probe Spectroscopy

B. Tiu, P. Delparastan, et al., ACS Appl. Mater. Interfaces, 2019.



# Mussel-Inspired PSAs: Underwater Shear

B. Tiu, P. Delparastan, et al., *ACS Appl. Mater. Interfaces*, 2019.



**Shear**



# Summary

## 1. Mussel Adhesion

- unusual adhesive proteins

## 2. Examples of Mussel-Inspired Adhesives

- Medical Adhesives
- Consumer Adhesives



February 2019

## Collaborators

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H. Duan	N. Scherer	P. Levkin
K. Shull	C.-H. Ahn	G. Liu
D. Kaufman	Y. Ren	S. Leeuwenburgh
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M. Textor	<b>M. Ehrbar</b>	
N. Spencer	<b>H. Lee</b>	



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