

Seaweed Research Symposium
Marine Institute
January 22, 2009



University College Dublin
An Coláiste Ollscoil, Baile Átha Cliath

Current Algal Research

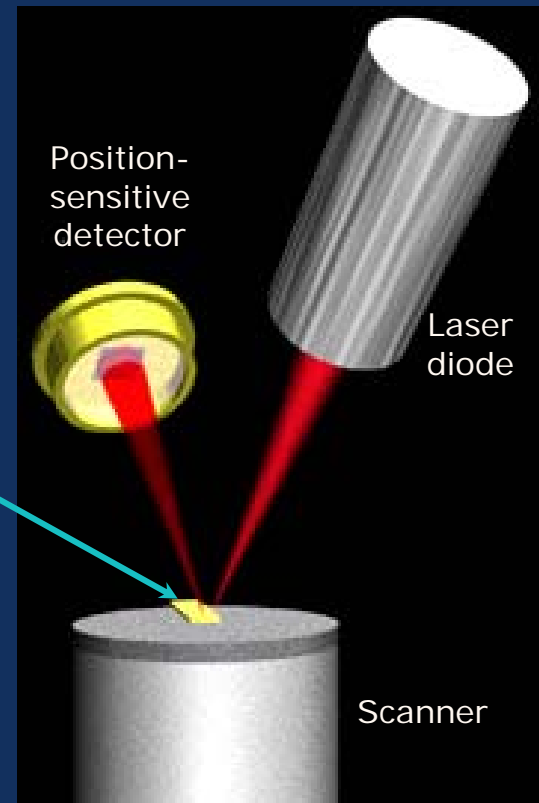
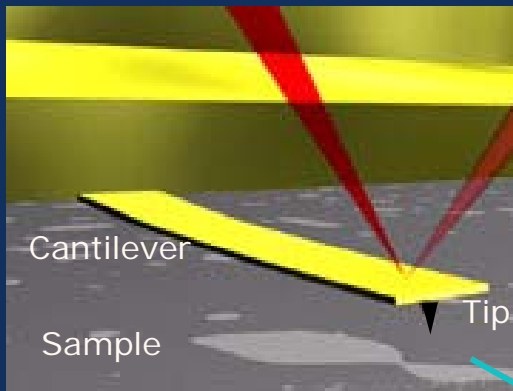
Nanoscale mechanics of algal adhesives towards the development of novel, biomimetic adhesives

Role of Nanobiology



Nanoscale interactions often underpin the underlying principles of how materials function

Measurements at the Nanoscale Atomic Force Microscopy



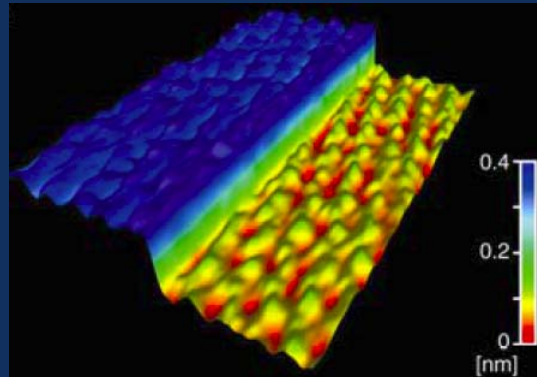
State-of-the-art technique not commonly applied to biological systems

Atomic Force Microscopes in the UCD Nanoscale Function Group

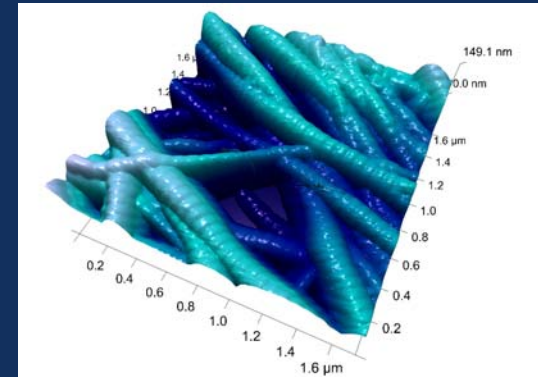
- 4 X Commercial AFMs
- 2 X Ultra-Low noise AFMs
- 1 X Combined Confocal-TIRF-AFM



Pine pollen

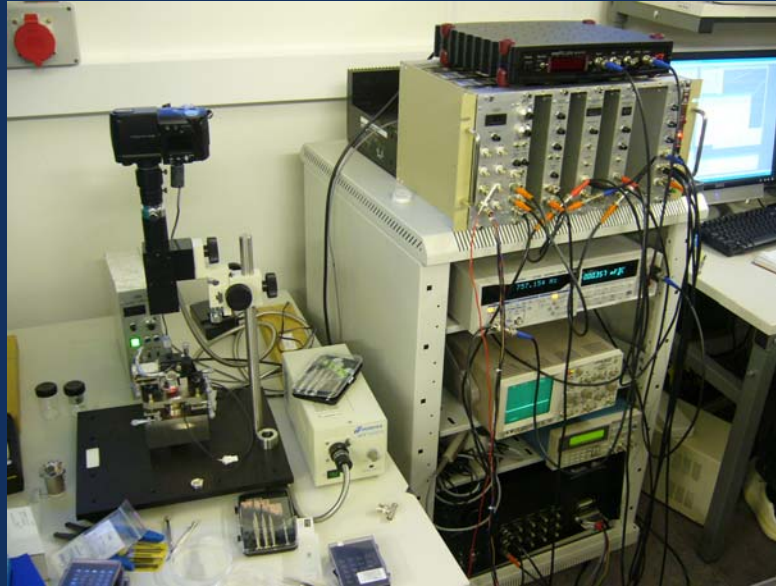


Imaging lipid bilayers



Type 1 Collagen

Ultra low noise AFM



90 pm resolution, 1 pN
force sensitivity.



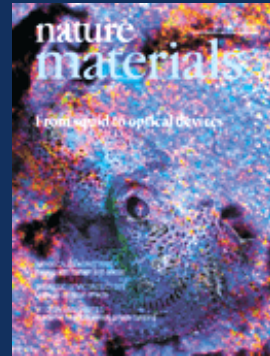
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AFM not accepted as an established tool
for biology (yet)

Principles of operation are difficult to
grasp outside physics/electrical
engineering disciplines



Recent Marine Materials Research



Marine glass sponge
Aizenberg et al. 2005
Science 309



Sea cucumber skin
Capadona et al. 2008
Science 319



Squid reflectins
Kramer et al. 2007
Nature Materials 6



Squid beaks
Miserez et al. 2008
Science 319



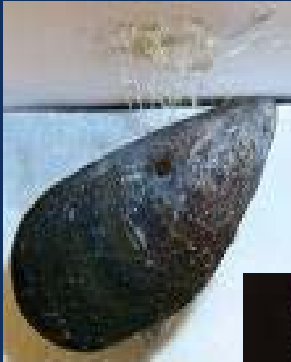
Polychaete jaws
Lichtenegger et al. 2002
Science 298

High profile work from UCSB in the past 5 years

Collaborative work of the Waite, Stucky, Hansma & Morse groups

We have expertise and instrumentation in place across Ireland to start making an impact in this area

Natural Marine Adhesives and Cements



Potential biomimetic development of aqueous bioadhesives for biomedical applications

Urban Biofouling by Subaerial Algae



Dublin



Galway



Dublin

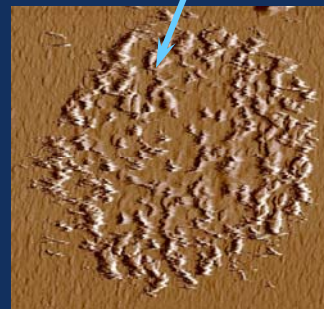
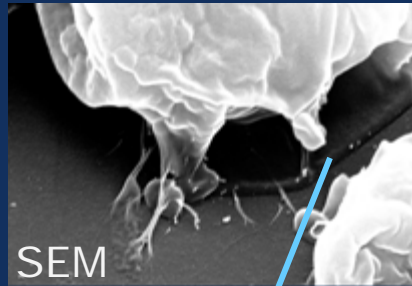


Limerick

Nanoscale Mechanical Response of Adhesive

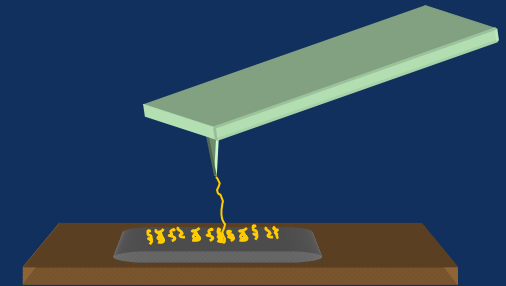


Chlorella angustoeilipsoidea

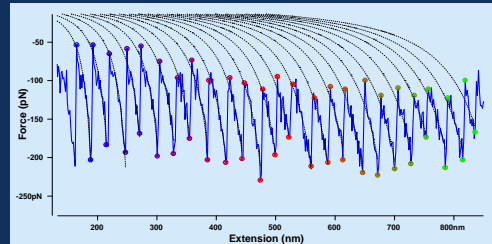
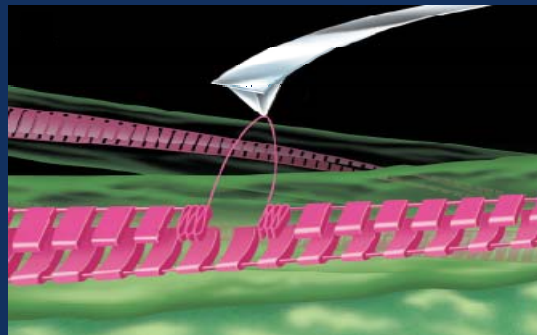
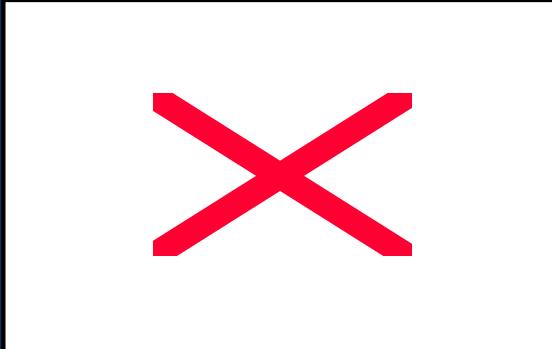


AFM

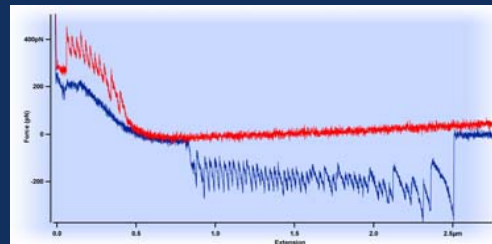
Scan: 5 μm



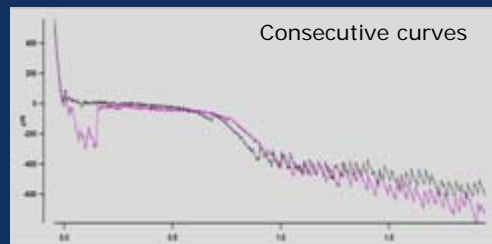
Mechanically Attractive Features of Nanostructured Protein Determined at the Nanoscale



(a) Mechanical strength (sawtooths)



(b) High degree of symmetry



(c) Self-healing (self-assembles)

Key Papers:

Mostaert et al. (2006). *J. Biol. Phys.* 32: 393-401

Mostaert & Jarvis (2007). *Nanotechnology* 18: 044010

Mostaert et al. (2009) *J. Adhesion* (in press)

Abalone
Haliotis sp.

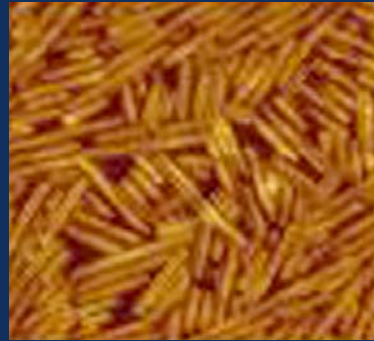


Functional and pathogenic amyloid

Non-pathogenic, physiological amyloid Materials applications in nature



Curli -
E. coli biofilm



Hydrophobins -
Fungal coats



Chorion -
Silkworm & Fish



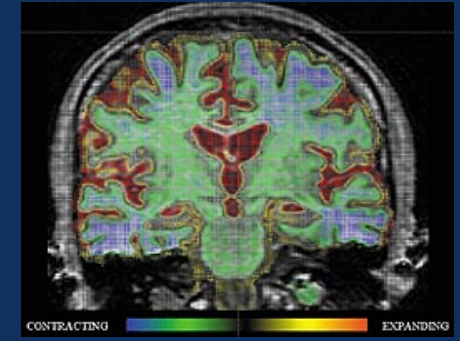
Silk production



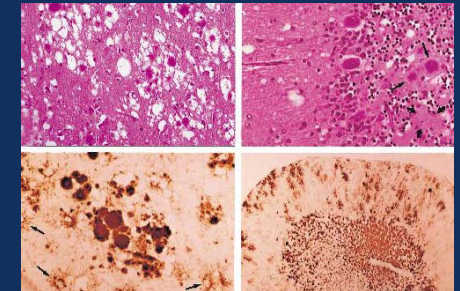
Hagfish slime



Pathogenic amyloid



Neurodegenerative diseases
e.g. Alzheimer's, Parkinson's



Prion diseases,
Type II diabetes

Where do we go from here?

Commercial possibility of producing adhesives that exploit the mechanical role of amyloid for adhesive strength



Where do we go from here?

3 patent applications



Commercial interest from Ashland Inc,
Henkel Loctite Ireland, Biomet Microfixation

Summary

Research Opportunities

- Nanoscale interactions often underpin the underlying principles of how materials function
- Looking at biomaterials at the molecular level may provide a short-cut for materials development
- Major opportunities for exploring adaptations of subaerial algae to environmental stress: potential discovery of useful natural products such as osmolytes and mycosporine-like amino acids
- Local diversity, facilities and expertise provides motivation for collaboration



Past Algal Research

Physiological adaptations of algae to environmental stress



Mangroves (Iriomote, Japan)

Past Algal Research

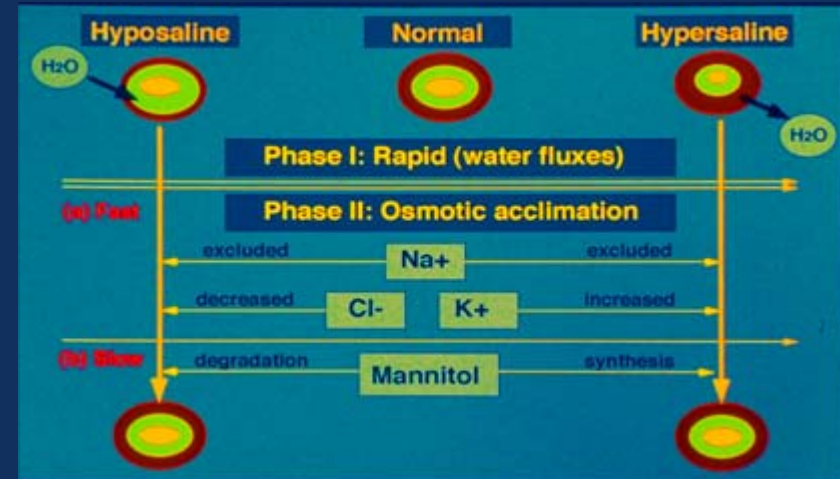
Adaptations of mangrove algae to salinity stress

Accumulation of compatible solutes

Caloglossa (mannitol)

Bostrychia (sorbitol, dulcitol)

Catenella (floridoside)



Key Publications:

Karsten, West, Mostaert, King, Kirst 1992 *J. Plant Physiol.* 140, 292-297

Mostaert, Karsten, King 1995 *Phycologia* 34, 501-507

Mostaert, Karsten, King 1995 *Phycol. S. Res.* 43, 215-222

Mostaert, Orlovich, King 1996 *New Phytol.* 132, 513-519

Nanoscale Function Group UCD Conway Institute

