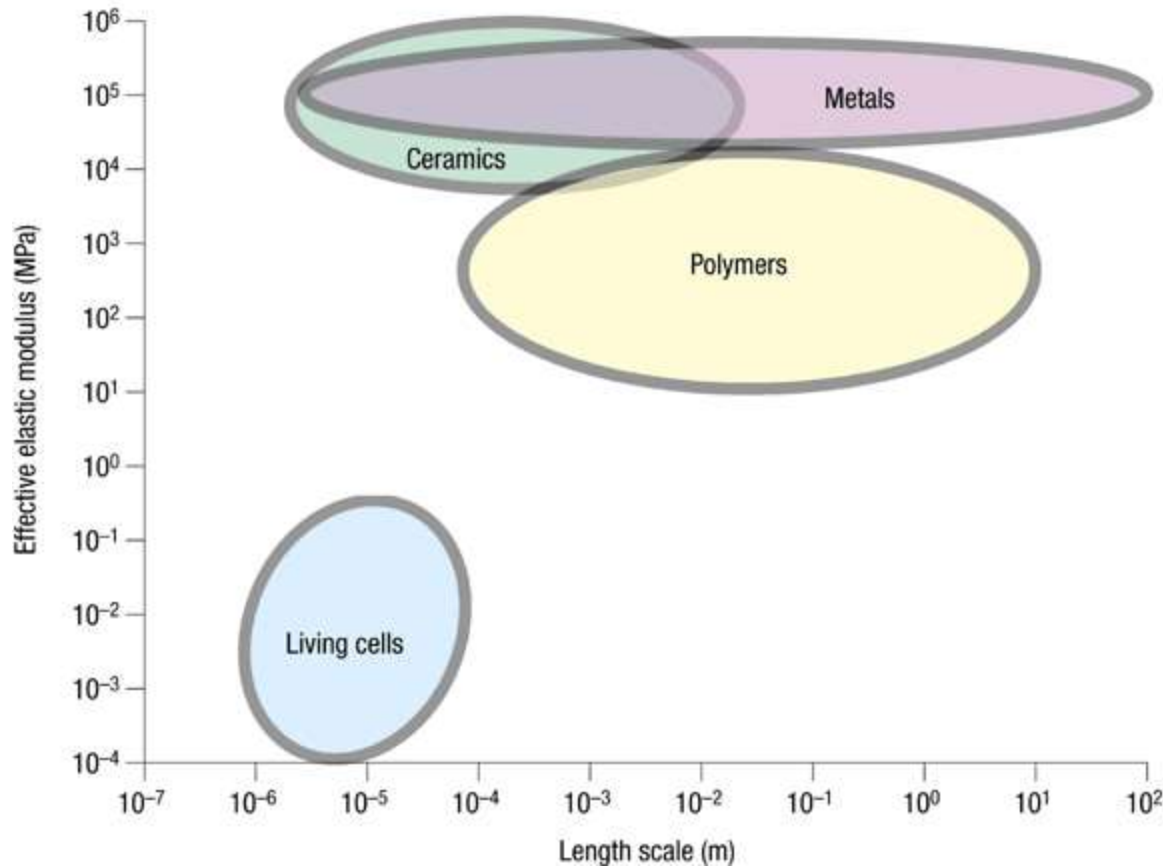


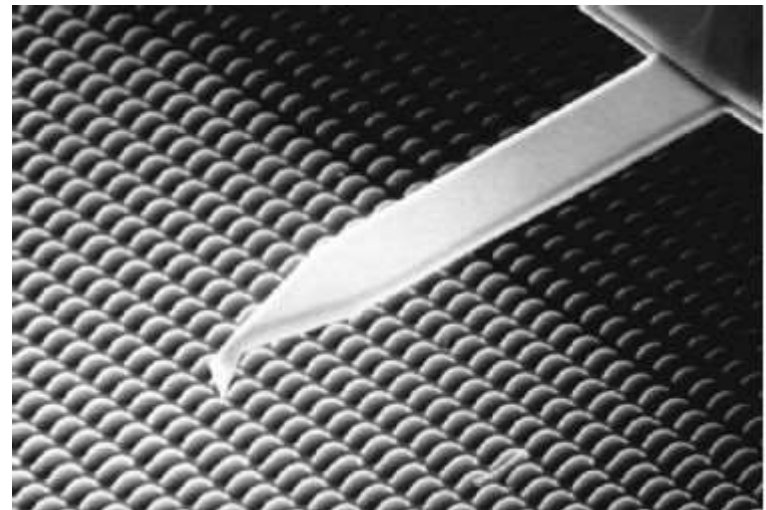
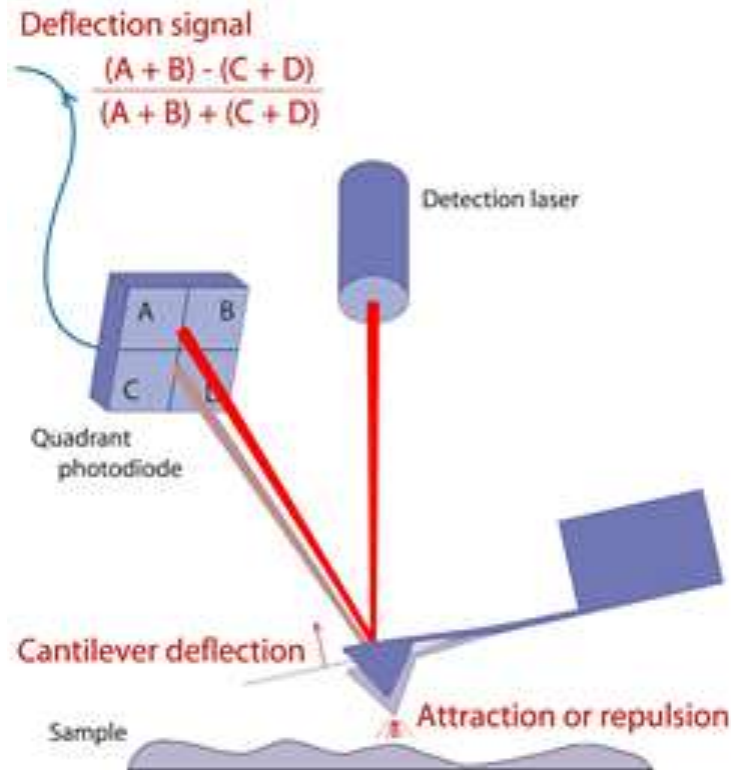
Young's Modulus



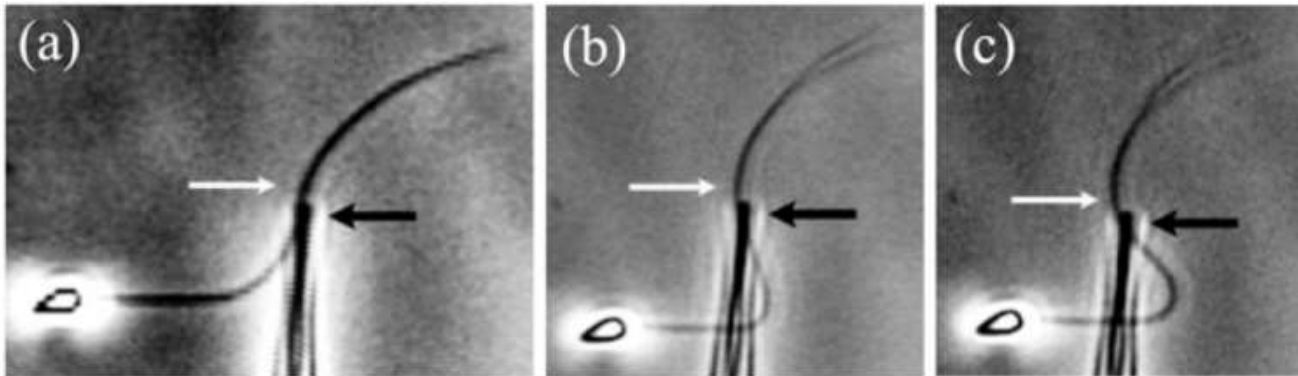
(Microstructured) Metamaterials:



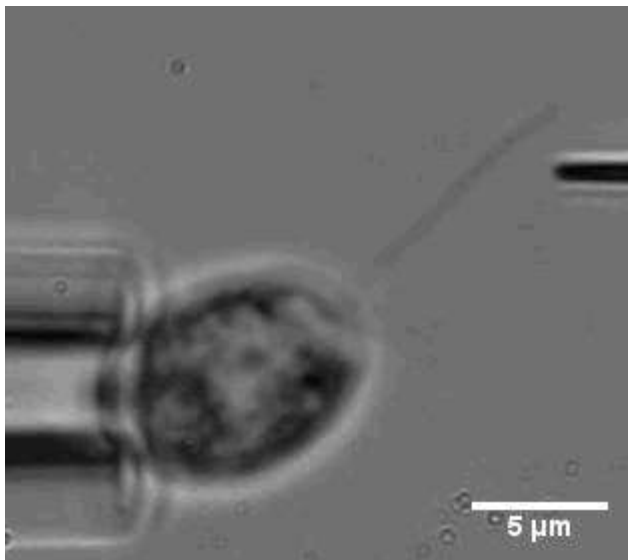
Beam theory: AFM cantilever



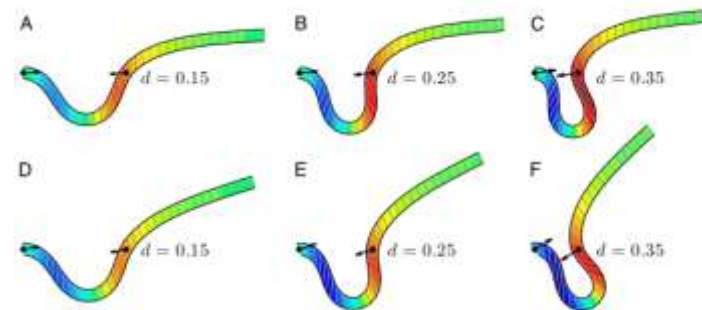
Beam theory: glass microprobe



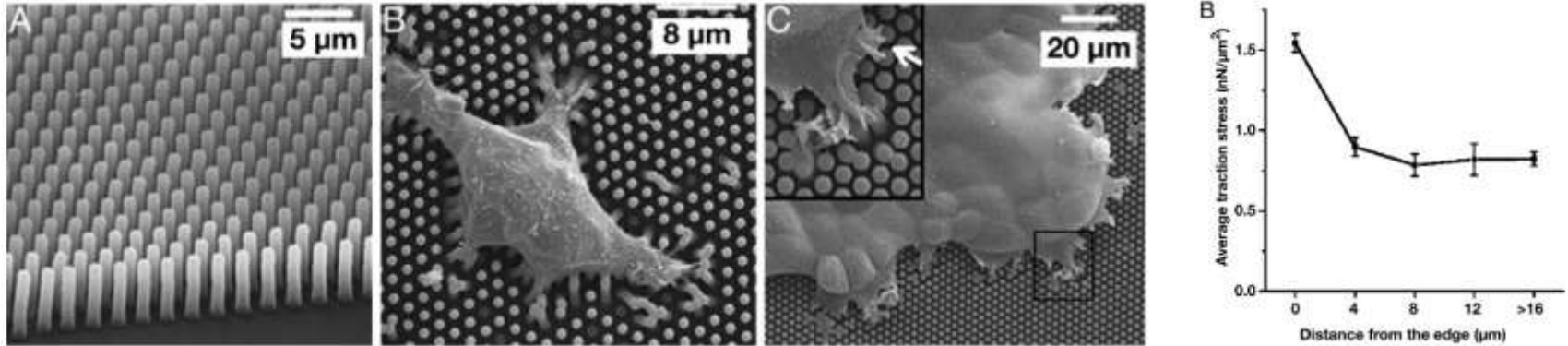
Pelle *et al.* Mechanical Properties of the Passive Sea Urchin Sperm Flagellum. *Cell Motil. Cytoskeleton* (2009)
Gadêlha *et al.* The counterbend phenomenon in flagellar axonemes and cross-linked filament bundles. *PNAS* (2013)



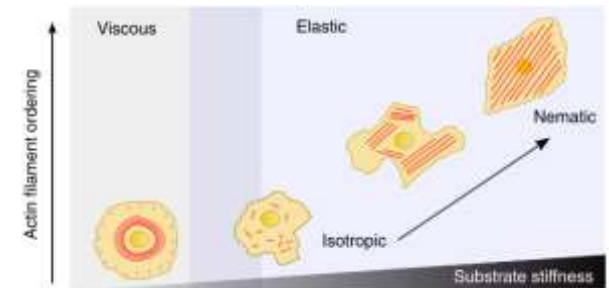
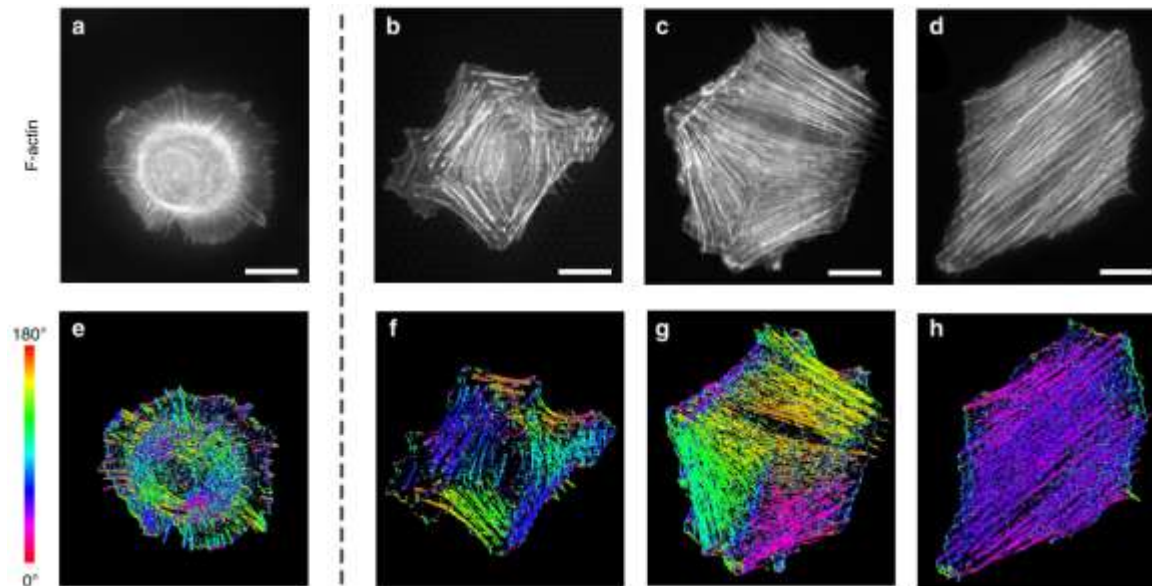
Counter-bending by internal cross-linking:



Beam theory: micropillar-substrate



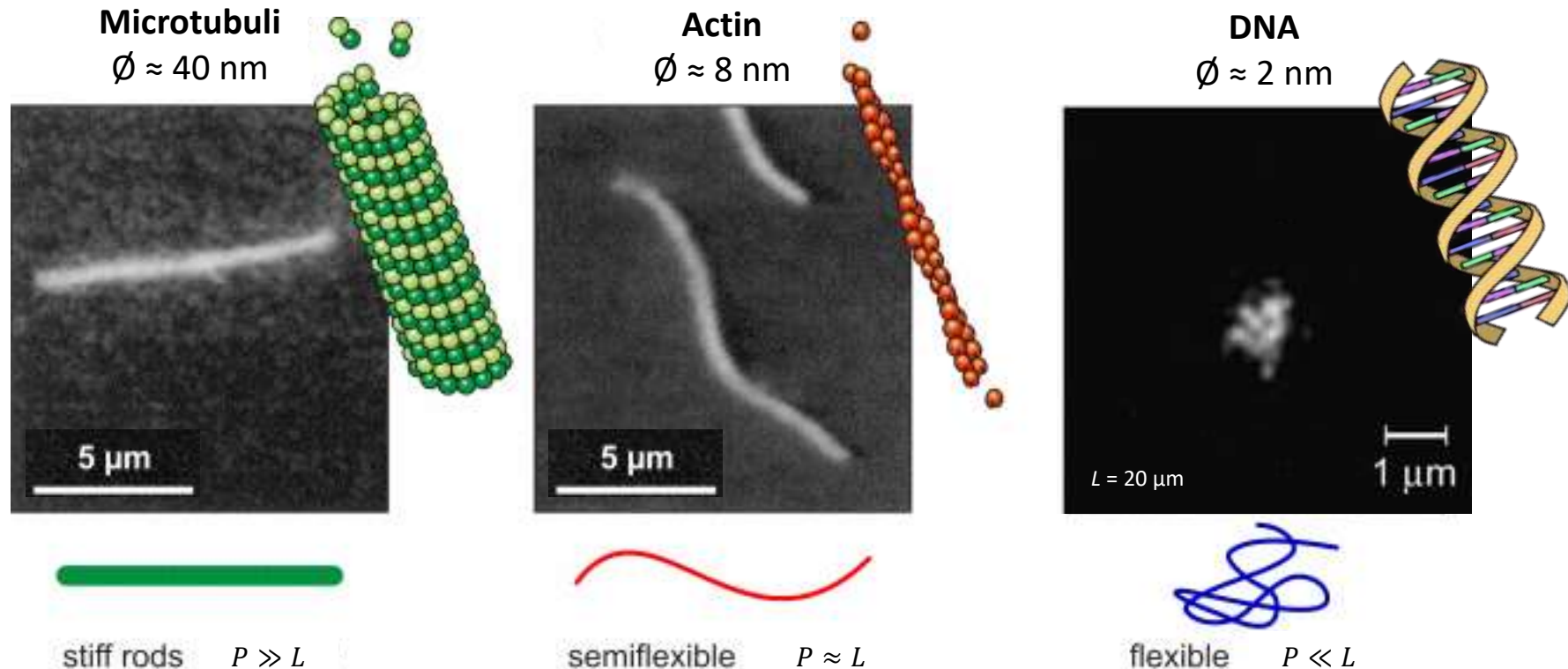
du Roure *et al.* PNAS **102** (2004)



Gupta *et al.* Nature Comm. **6** (2015)

Thermal Fluctuations of Bio-Filaments

Examples for different persistence lengths from cell biology:



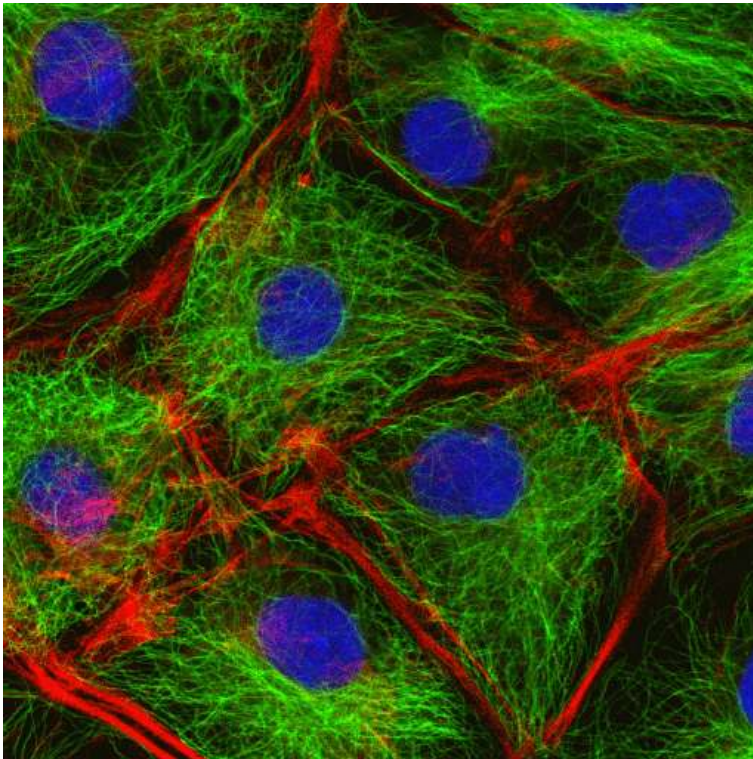
Bonthuis *et al.* Phys. Rev. Lett. **101**, 108303 (2008)
DOI: 10.1103/PhysRevLett.101.108303

<http://www.uni-leipzig.de/~pwm/web/?section=introduction&page=cytoskeleton>

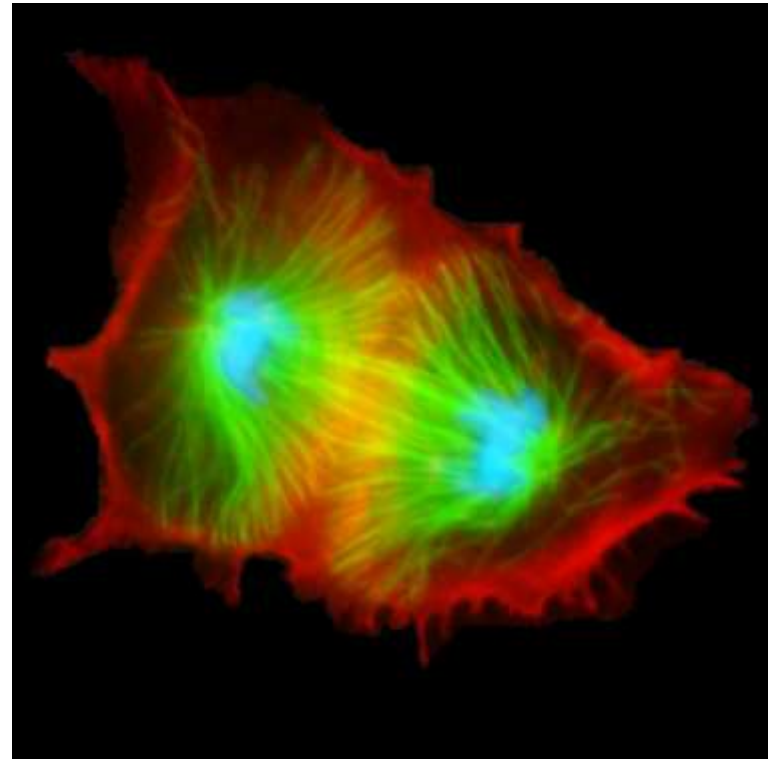
“Persistence length” of
raw vs. cooked spaghetti:



Different Persistence Lengths in the Cell



cytoskeleton with microtubules (green),
actin filaments (red), and the nucleus (blue).
<http://bscb.org>



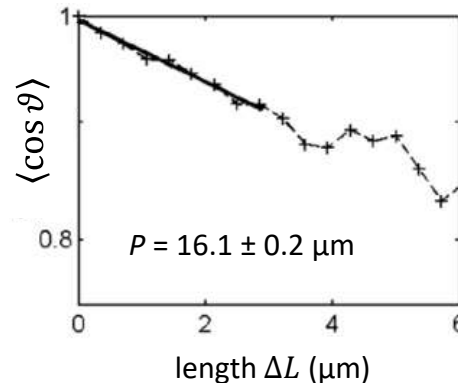
PtK1 cell about 5 minutes after anaphase-onset. F-actin (red),
microtubules (green), and DNA (blue).
<http://www.unc.edu/~jccanman/pictures.html>

Thermal fluctuations of bio-filaments

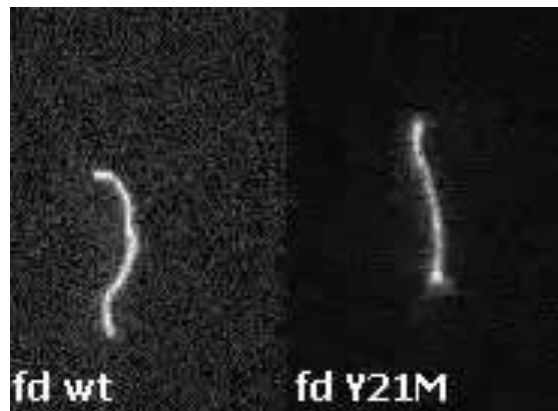
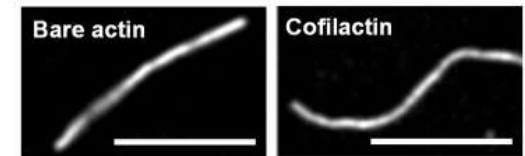


Filaments were fluorescently labeled and imaged while confined between two glass slides.

Brangwyne *et al.* Biophys. J. (2007)
DOI: 10.1529/biophysj.106.096966
http://www.brandeis.edu/departments/physics/complexfluids/dogic/research/actin_pol.html



Le Goff *et al.* PRL 2002



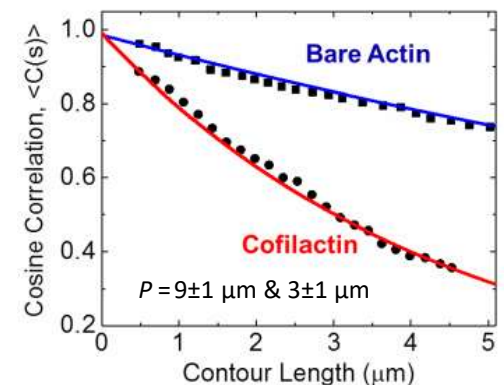
fd virus infecting E.Coli bacteria

wt: $P = 3 \pm 1 \mu\text{m}$

Y21M mutant: $P = 10 \pm 2 \mu\text{m}$

(single point mutation in amino-acid sequence of major coat protein, reduced infection efficiency)

Barry *et al.* Soft Matter 5 (2009)
DOI: 10.1039/B822478A



Graham *et al.* PLoS ONE 9 (2014)
DOI: 10.1371/journal.pone.0094766

The Persistence Length of Spaghetti

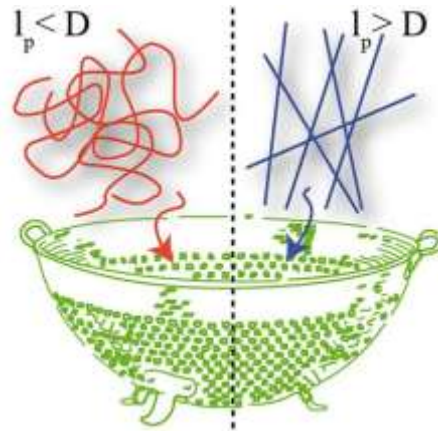
Seeman, Nanotechnology 17 (1999)
DOI: 10.1016/S0167-7799(99)01360-8
“The persistence length of spaghetti is about 1.5 cm”

https://en.wikipedia.org/wiki/Talk%3APersistence_length

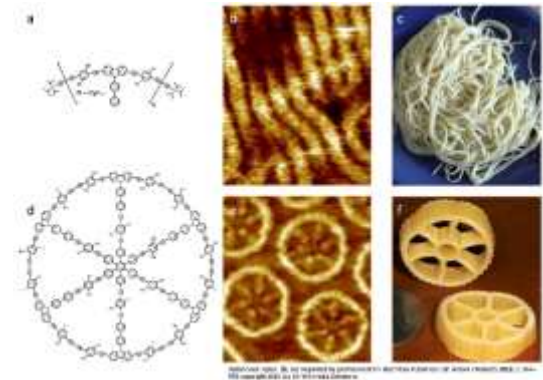


Thesis C. Müthel 2012
(Supervisor: Helmut Grubmüller, Jörg Enderlein)

“A raw spaghetti in a pot of water, for example, has a very high persistence length. In contrast a cooked spaghetti in water has a low persistence length.

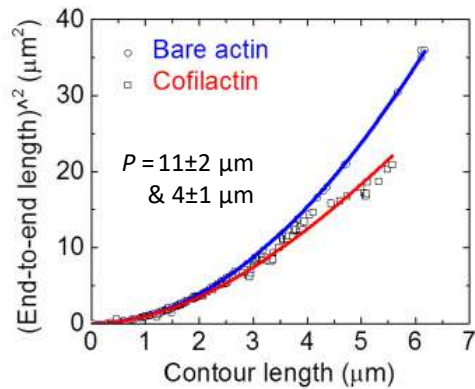
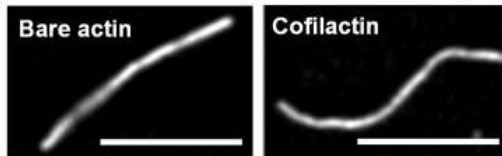


Auger *et al.* Eur. Phys. J. E **41** (2018)
DOI: 10.1140/epje/i2018-11674-y

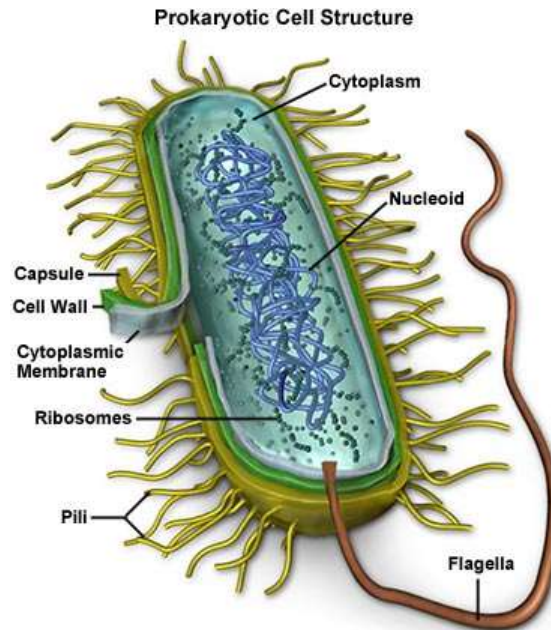


<https://www.chemie.uni-bonn.de/oc/forschung/arbeitsgruppen/jester-en/research> and
Aggarwal *et al.* Nat. Chem. **5** (2013)
DOI 10.1038/nchem.1758

End-To-End Distance



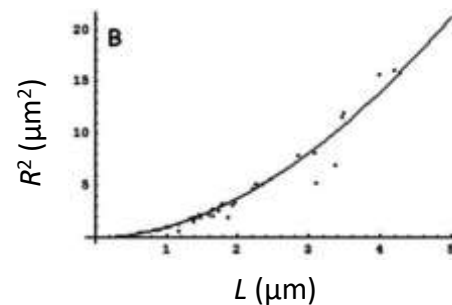
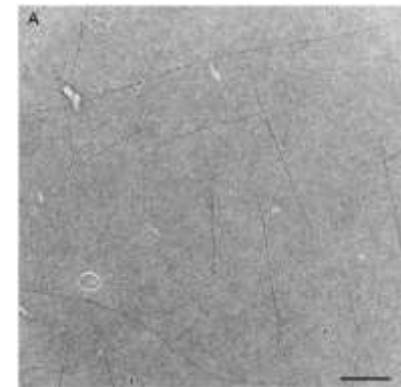
Graham *et al.* PLoS ONE 9 (2014)
DOI: 10.1371/journal.pone.0094766



<http://micro.magnet.fsu.edu/cells/bacteriacell.html>



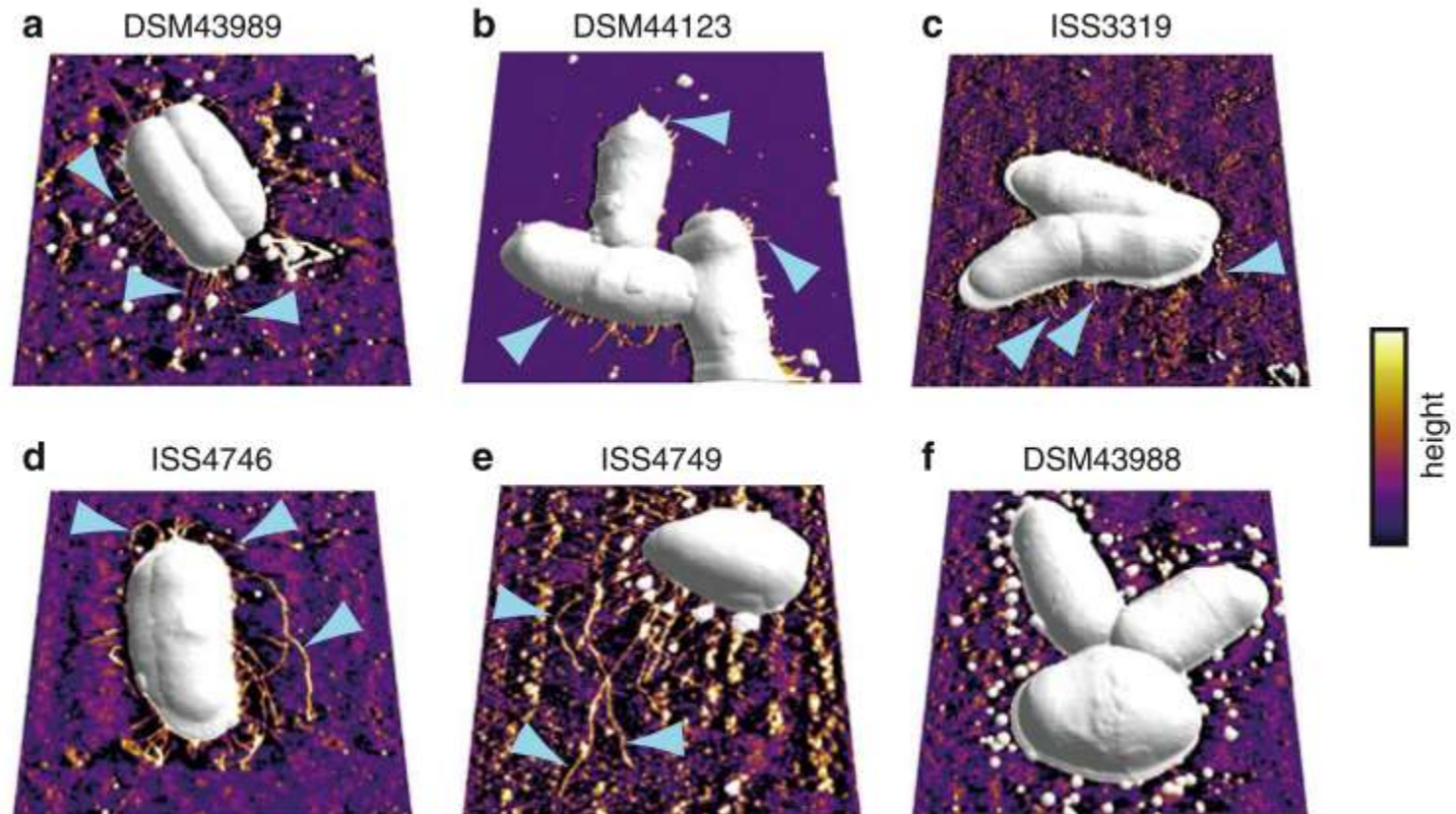
TEM of isolated pili:



Silverman *et al.* Integr. Biol. 2 (2010)
DOI: 10.1039/b917761b

Bacterial Pili

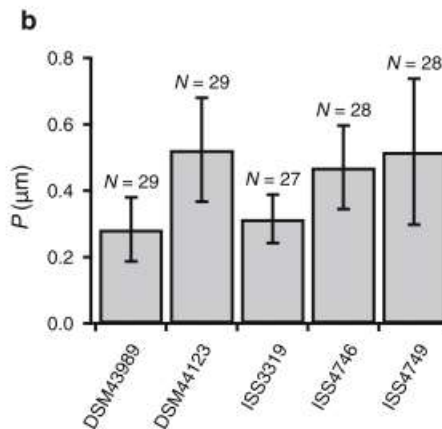
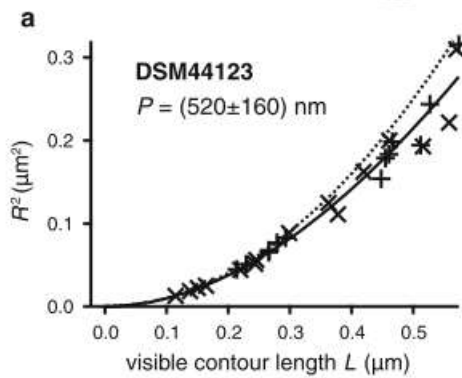
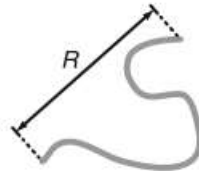
AFM images of diphtheriae bacteria of different strains



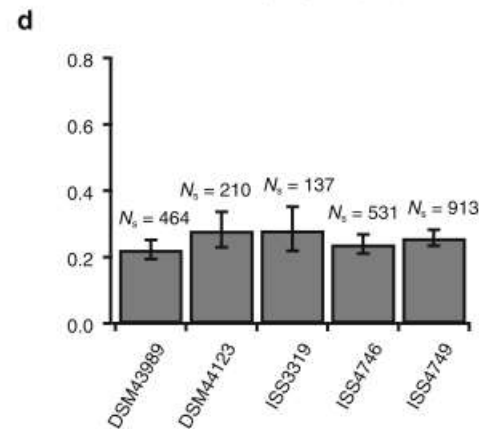
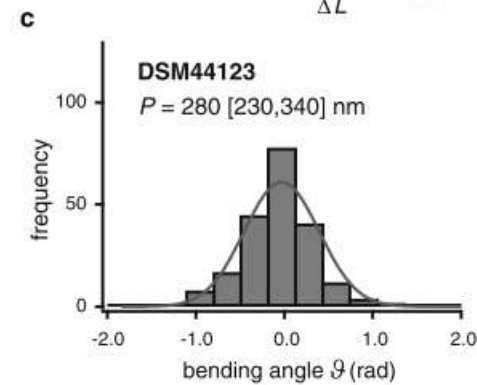
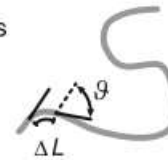
Rheinlaender *et al.* A Contour and persistence length of *Corynebacterium diphtheriae* pili by AFM. Eur. Biophys. J. (2012)

Bacterial Pili

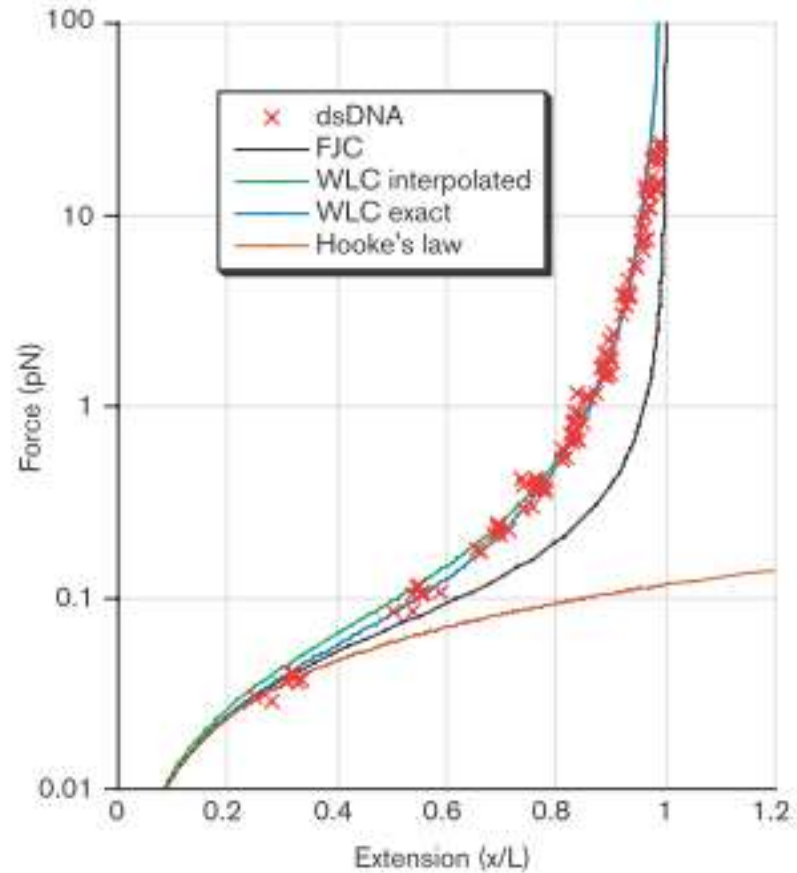
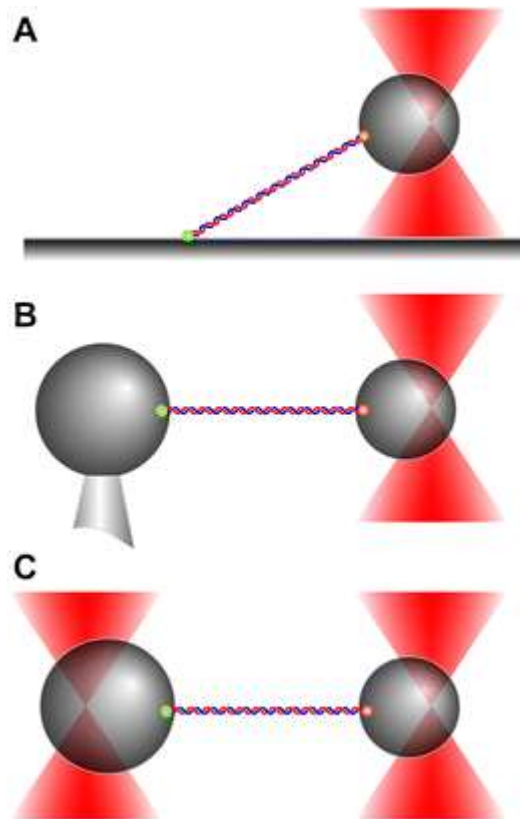
Method 1:
end-to-end distance



Method 2:
segment bending angles

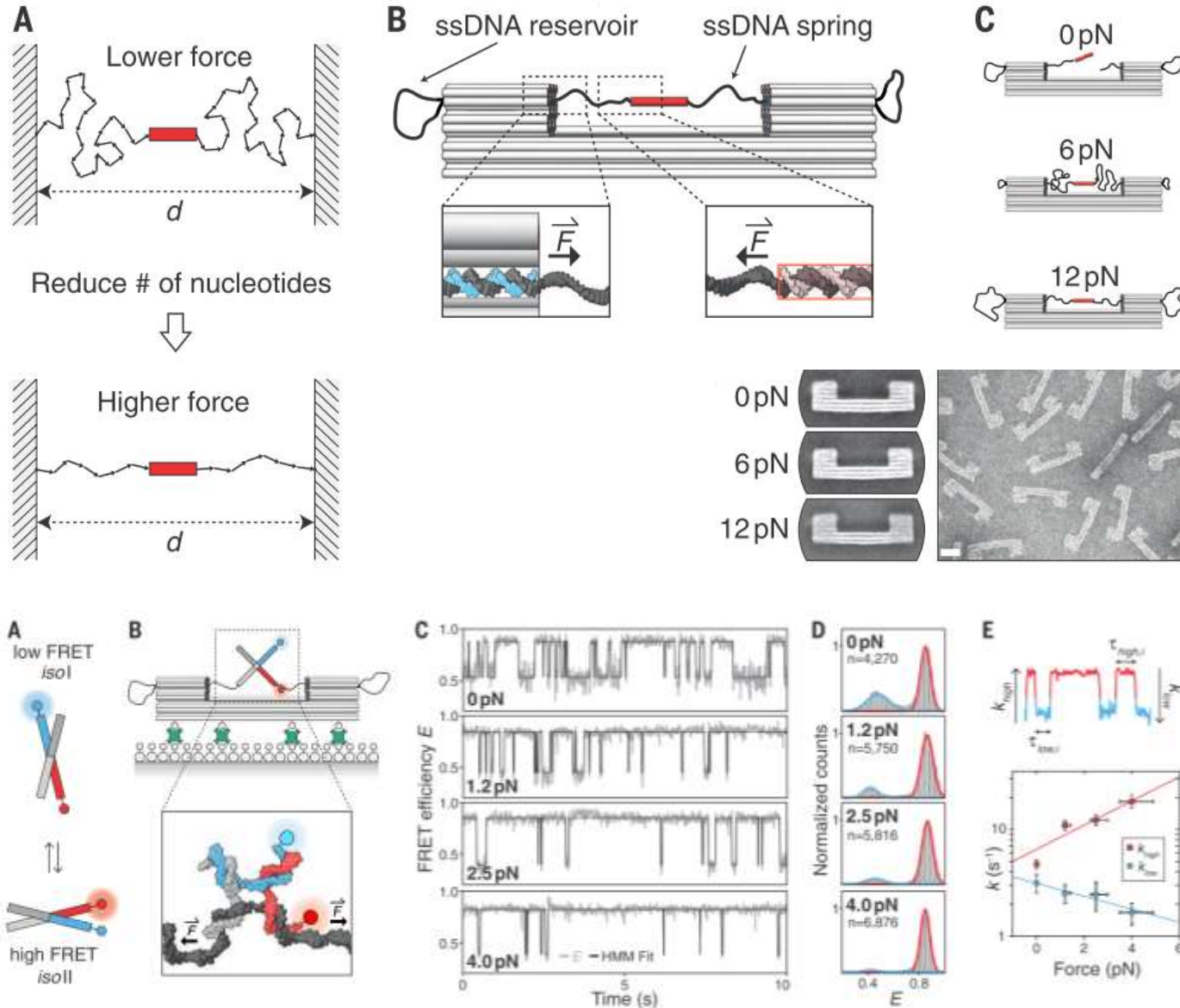


DNA: FJC vs. WLC



Bustamante *et al.* Curr. Opin. Struc. Biol. **10** (2000)
DOI: 10.1016/S0959-440X(00)00085-3

A DNA Origami-Based Force Sensor



The Persistence Length of Spaghetti

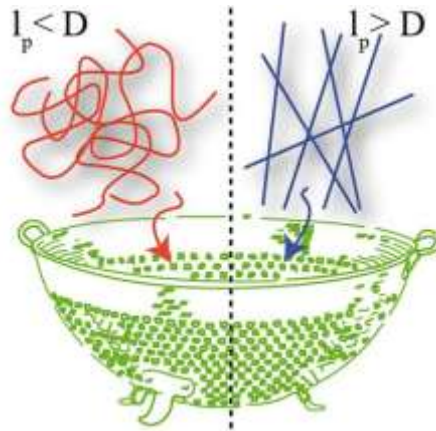
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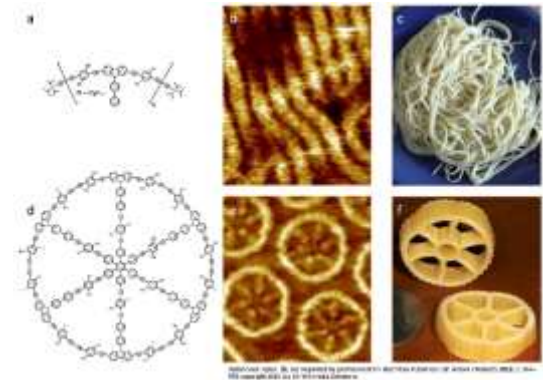


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<https://www.chemie.uni-bonn.de/oc/forschung/arbeitsgruppen/jester-en/research> and
Aggarwal *et al.* Nat. Chem. **5** (2013)
DOI 10.1038/nchem.1758