TECHNISCHE UNIVERSITÄT DRESDEN
Fakultät Mathematik und Naturwissenschaften, Professur für Physikalische Chemie, Mess- und Sensortechnik

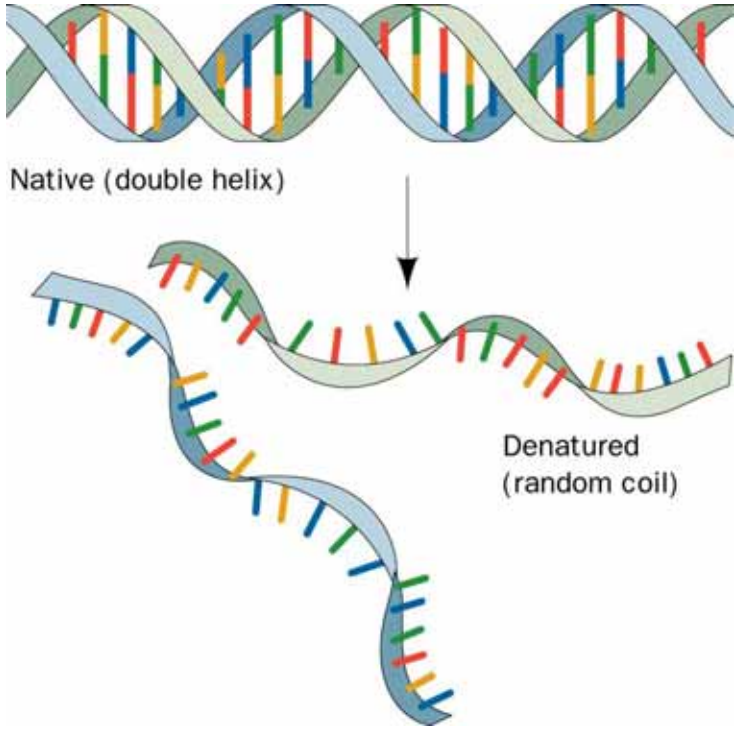
Konstruieren mit DNS

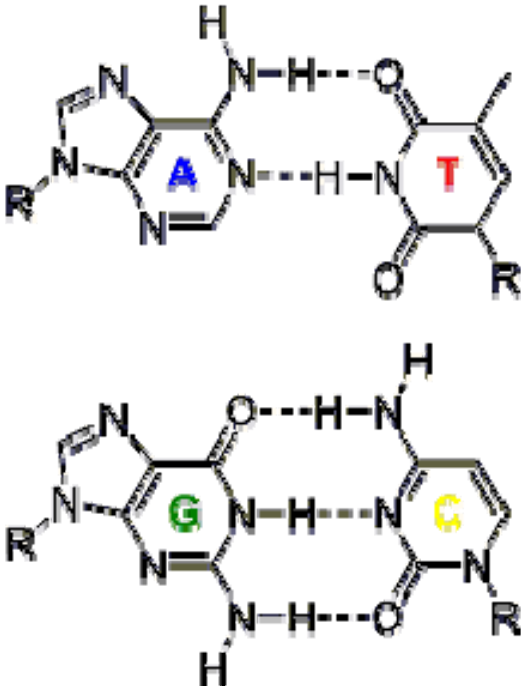
13th LEIBNIZ CONFERENCE OF ADVANCED SCIENCE
- NANOSCIENCE 2012 -
Lichtenwalde
26. - 27. April 2012

Michael Mertig
Physikalische Chemie, Technische Universität Dresden
&
Kurt-Schwabe-Institut für Mess- und Sensortechnik e.V. Meinsberg

michael.mertig@tu-dresden.de

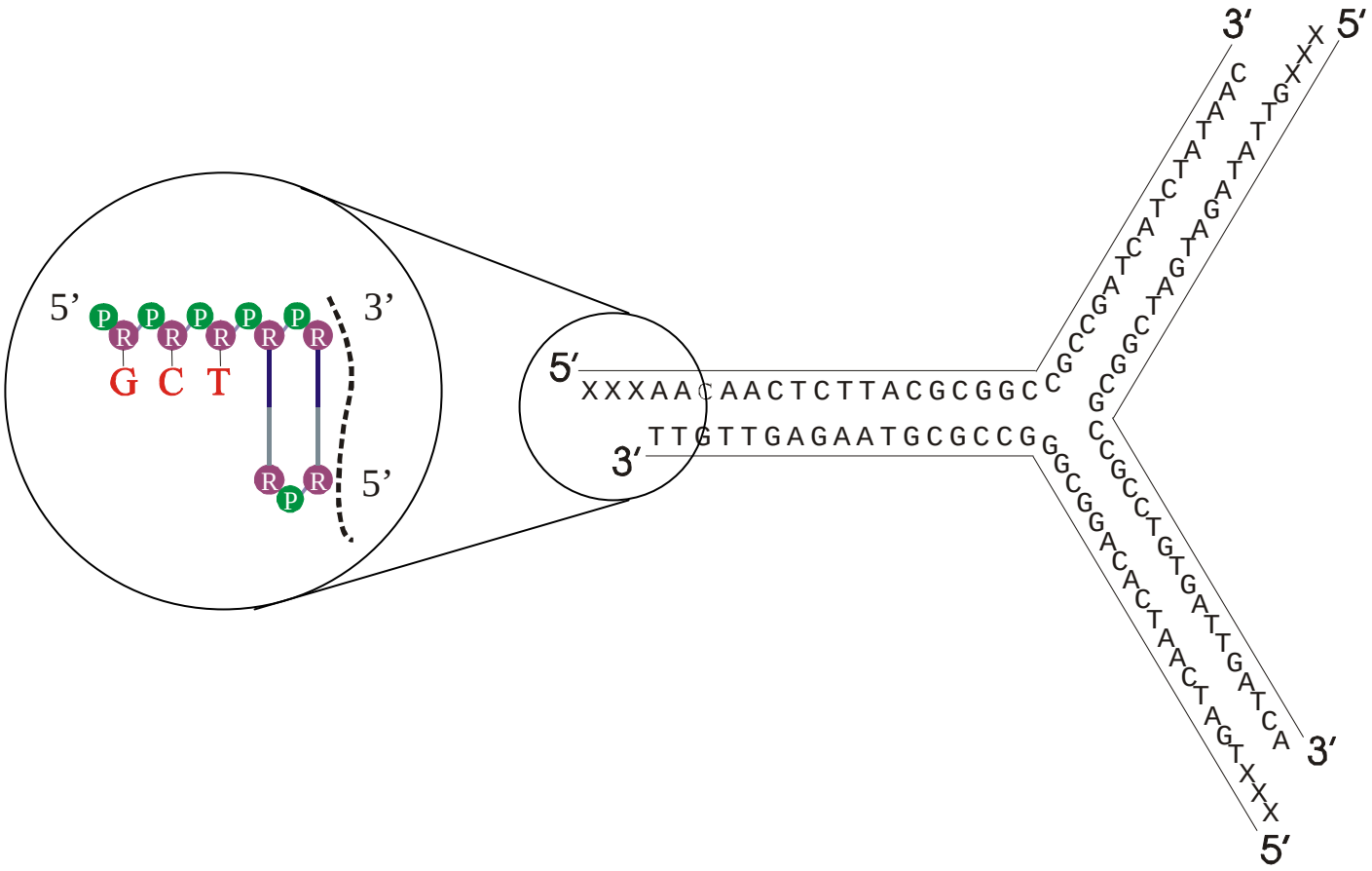
Die Watson-Crick-Basenpaarung





Nur A-T und C-G Basenpaarung erlaubt.

Design von künstlichen Strukturen

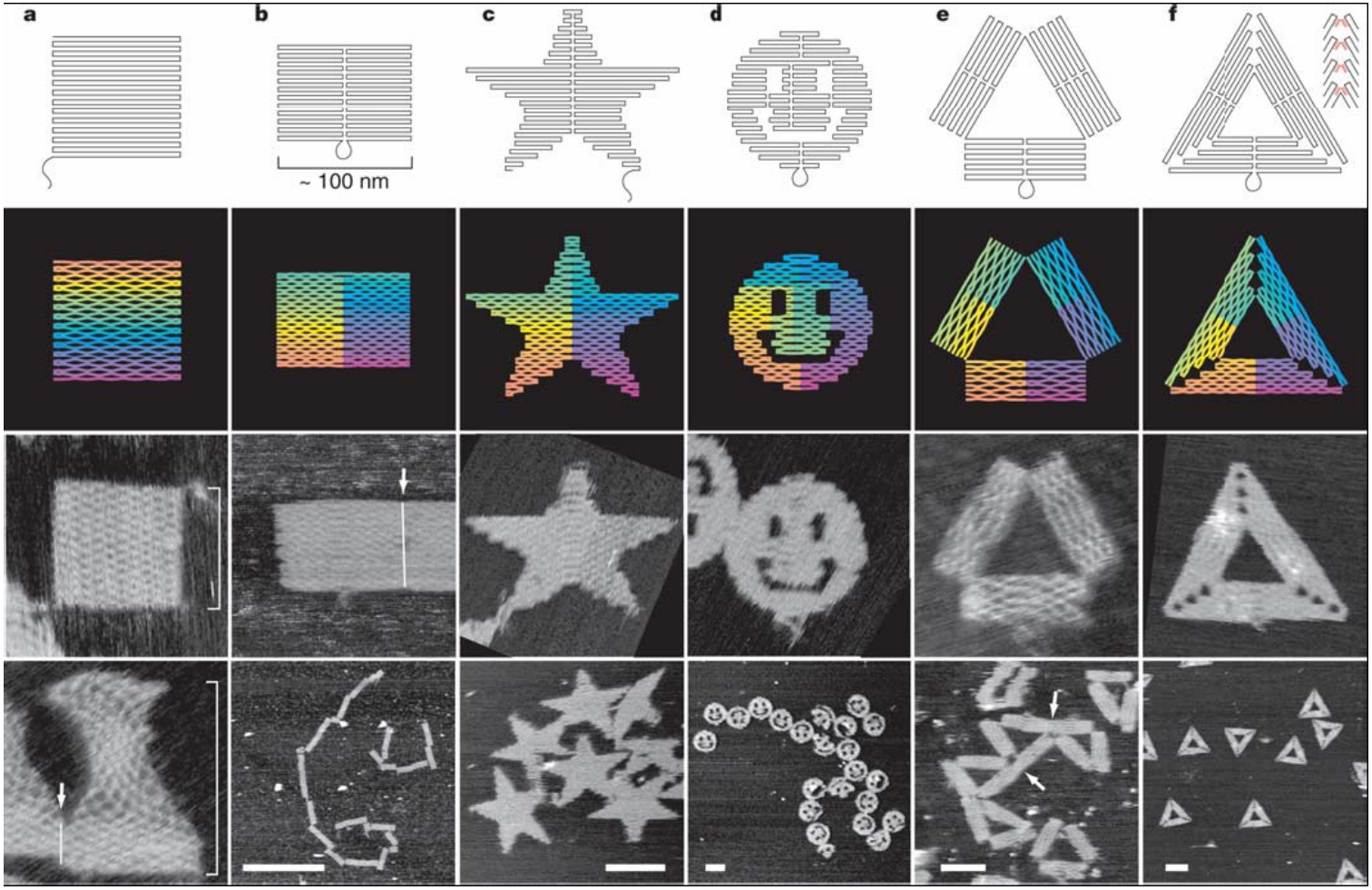


N.C. Seeman
Nucleic acid junctions and lattices
J. Theor. Biol. 99, 237-247 (1982)

DNA origami

By courtesy of S.M. Douglas, Harvard University

DNA origami



P.W.K. Rothemund, Nature 440, 297-302 (2006)

Outline

1. Origami nanotubes
2. Templated nanotube formation [1]
3. Chengde Mao' tubes [2,3]

---

[1] O. I. Wilner, R. Orbach, A. Henning, C. Teller, O. Yehezkeli, M. Mertig, D. Harries, I. Willner
Self-assembly of DNA nanotubes with controllable diameters
Nature Communications 2 (2011) 540

[2] H.P. Liu, Y. Chen, Y. He, A.E. Ribbe, C.D. Mao
Approaching the limit: Can one DNA oligonucleotide assemble into large nanostructures?
Angewandte Chemie, International Edition 45 (2006) 1942-1945

[3] T. L. Sobey, S. Renner, F. C. Simmel
Assembly and melting of DNA nanotubes from single-sequence tiles
Journal of Physics Condensed Matter 21 (2009) 034112

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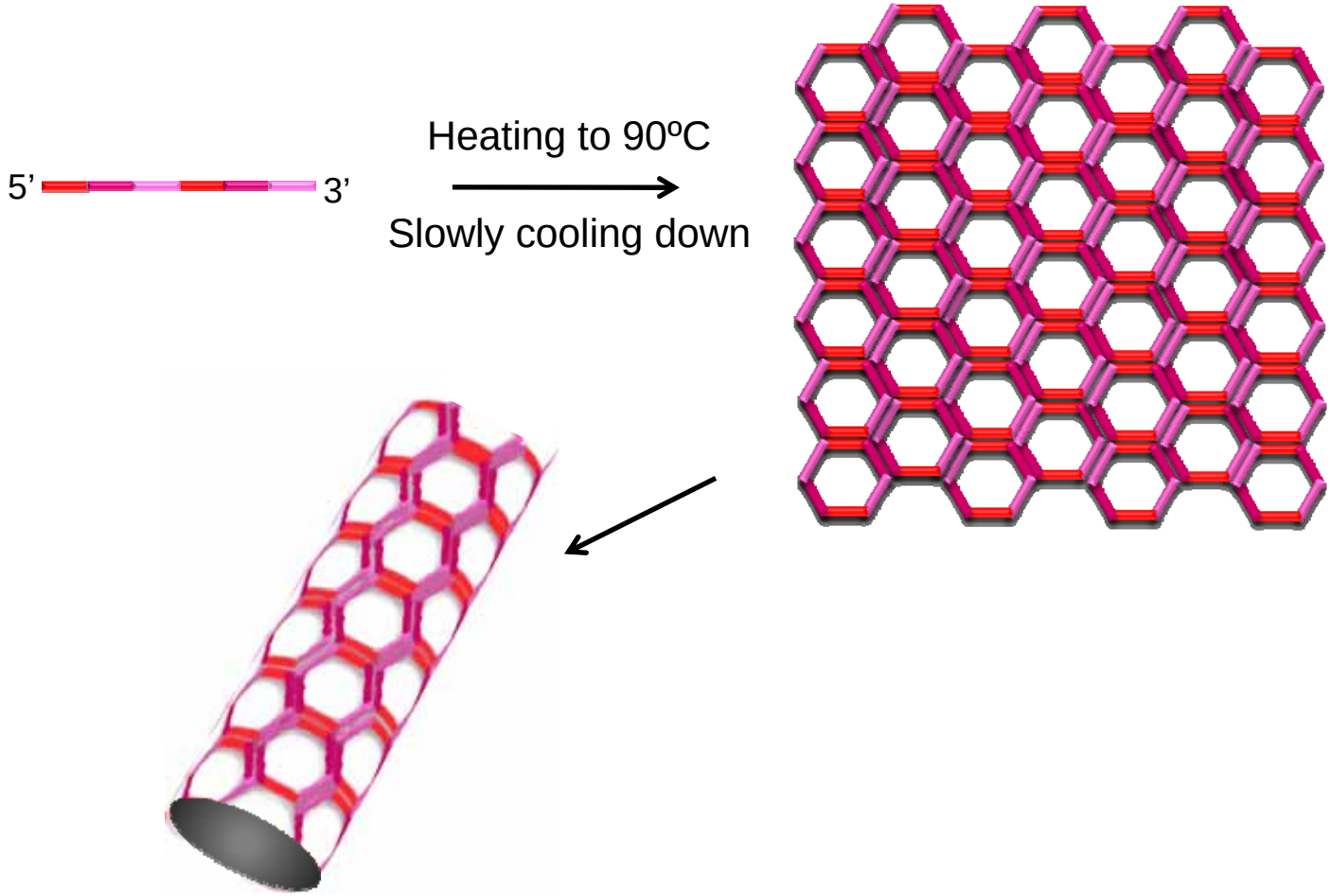
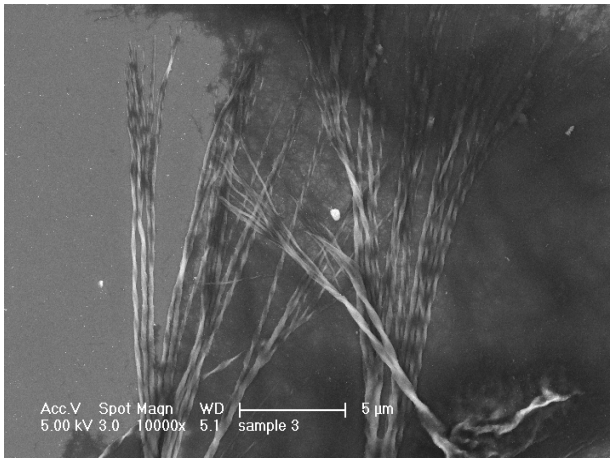
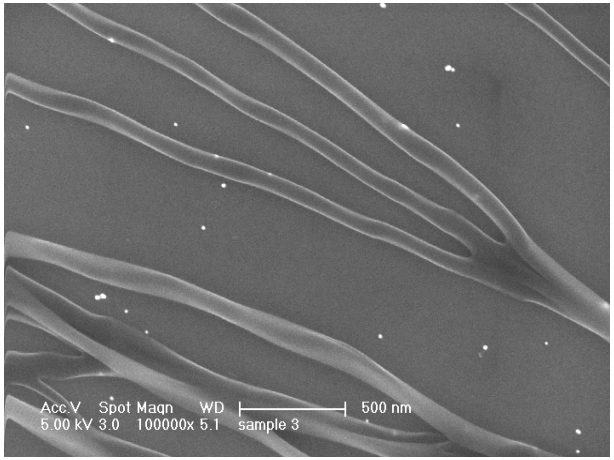
Hexagon-lattice DNA nanotubes

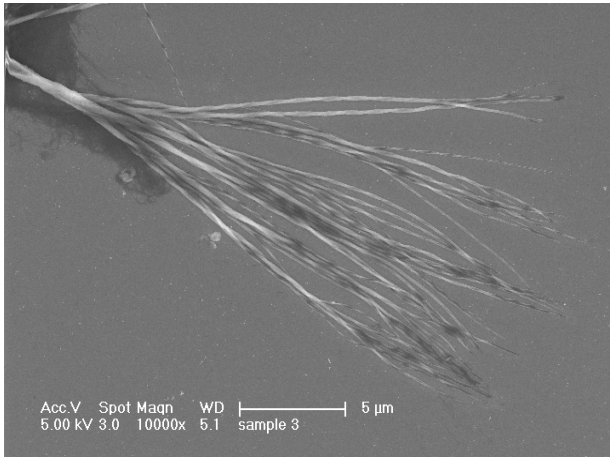


Nature Communications 2 (2011) 540

SEM of hexagon-lattice DNA nanotubes

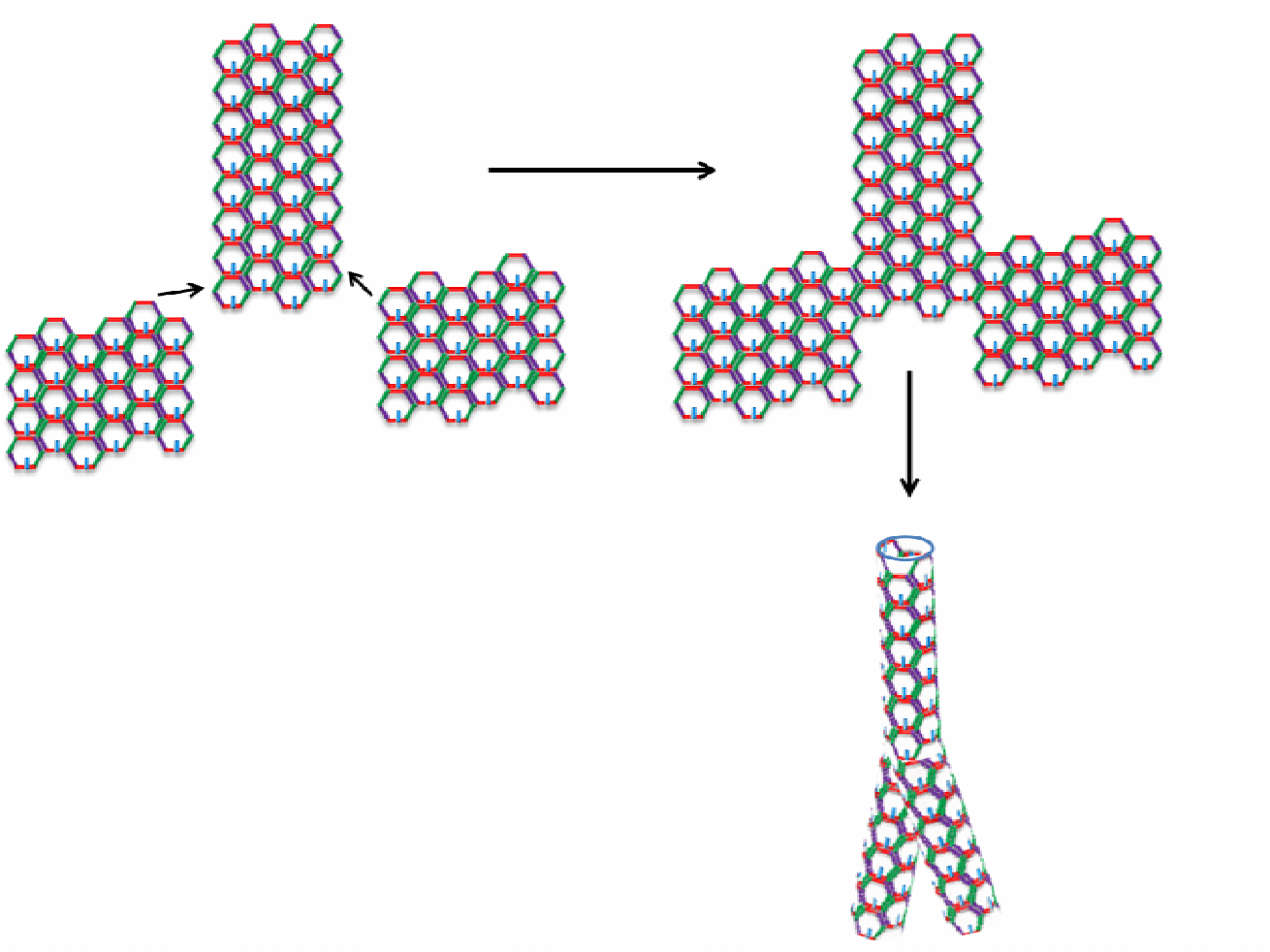






Nature Communications 2 (2011) 540

Branching of the hexagonal lattice



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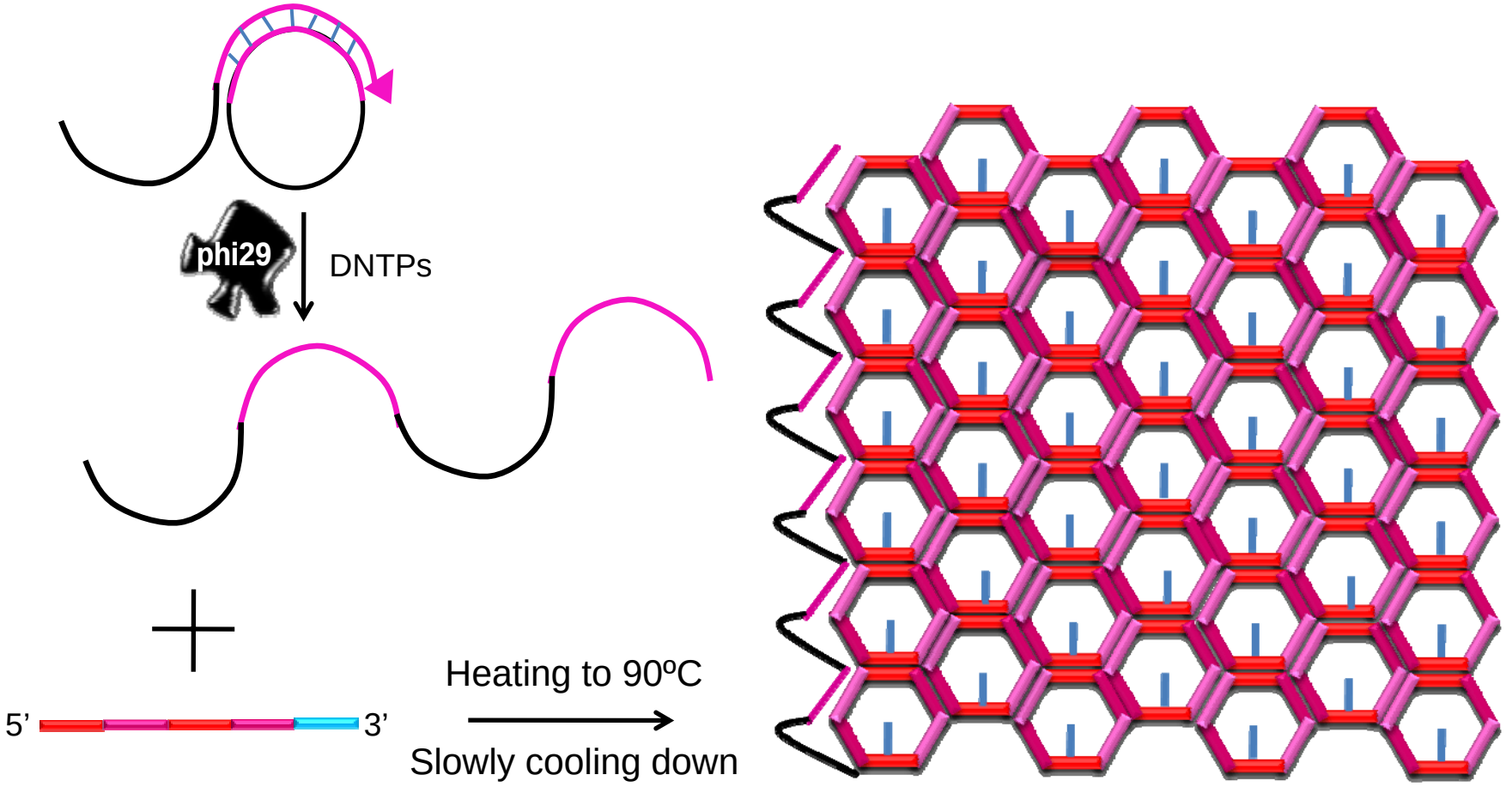
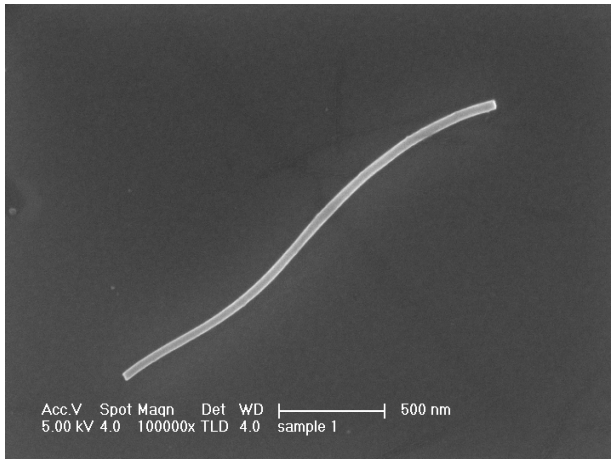
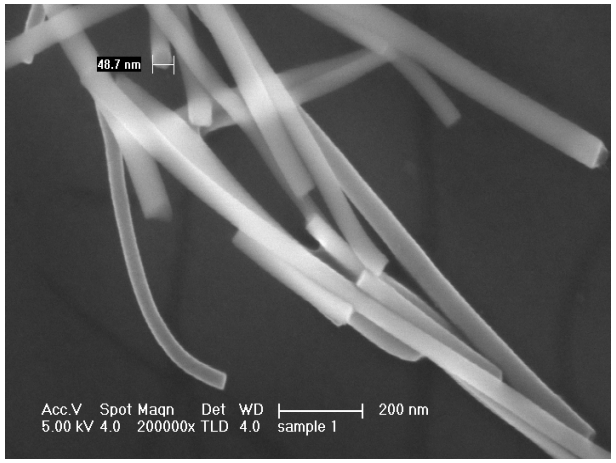
RCA-directed growth of DNA nanotubes

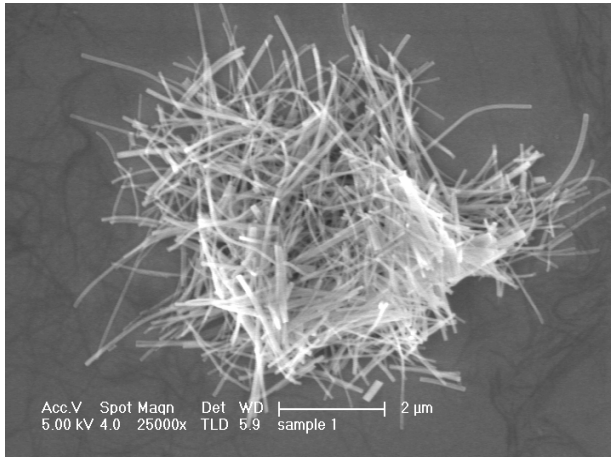


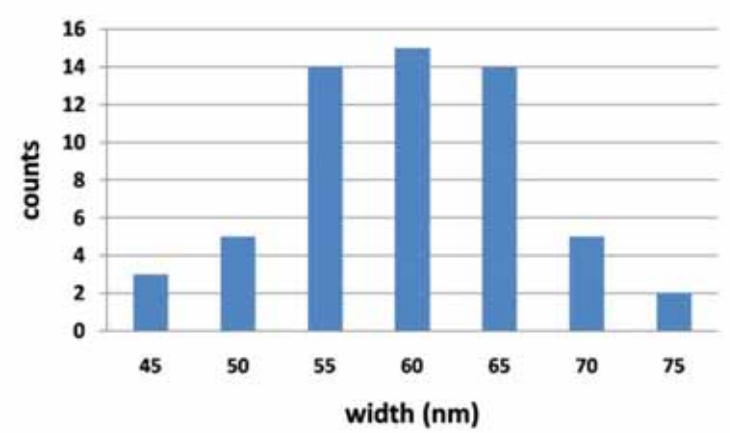
Nature Communications 2 (2011) 540

SEM of templated DNA nanotubes









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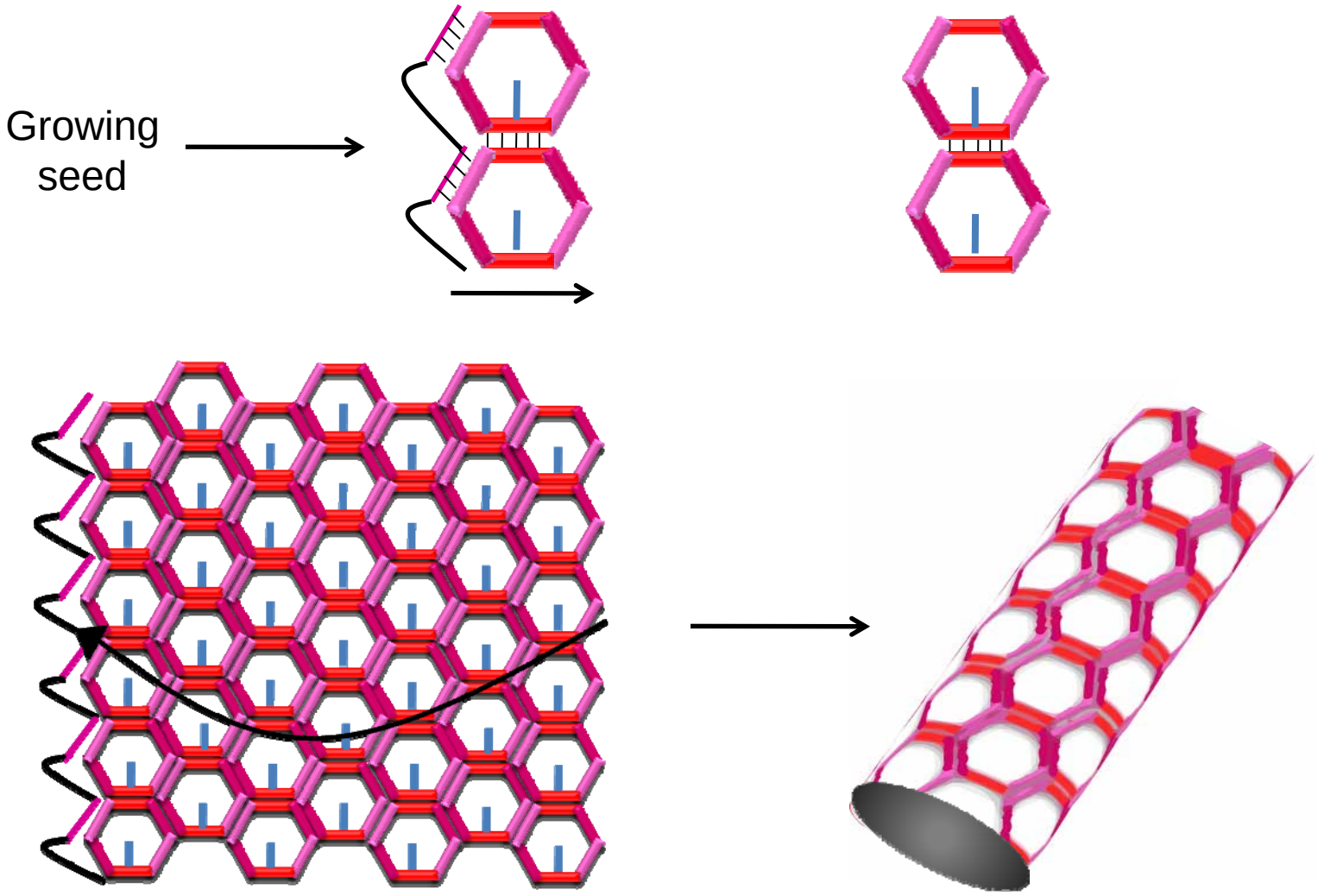
Why single nanotubes?



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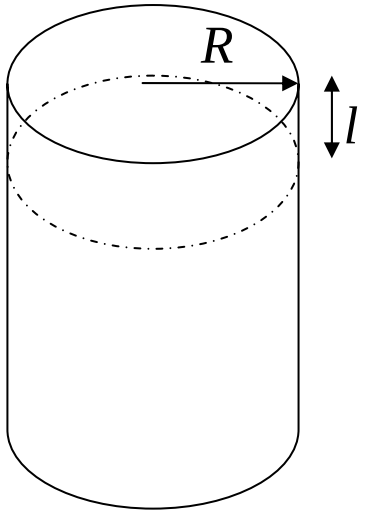
What controls the tube diameter?

$$F = F_{binding} + F_{bending}$$

Canham-Helfrich-Evans Equation

$$F_{bending} = 2\pi R l \times \frac{1}{2}\kappa \left(\frac{1}{R} - \frac{1}{R_0} \right)^2 \qquad F_{binding} = -l\varepsilon$$



$$R^* \sim \kappa/\varepsilon$$

When R > R tube formation is favored*

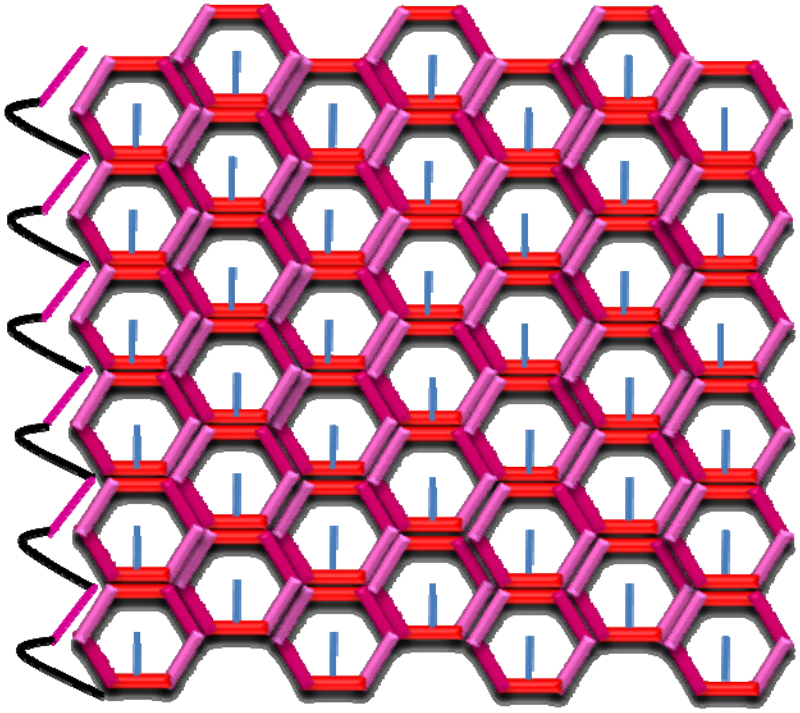
R - sheet's radius of curvature

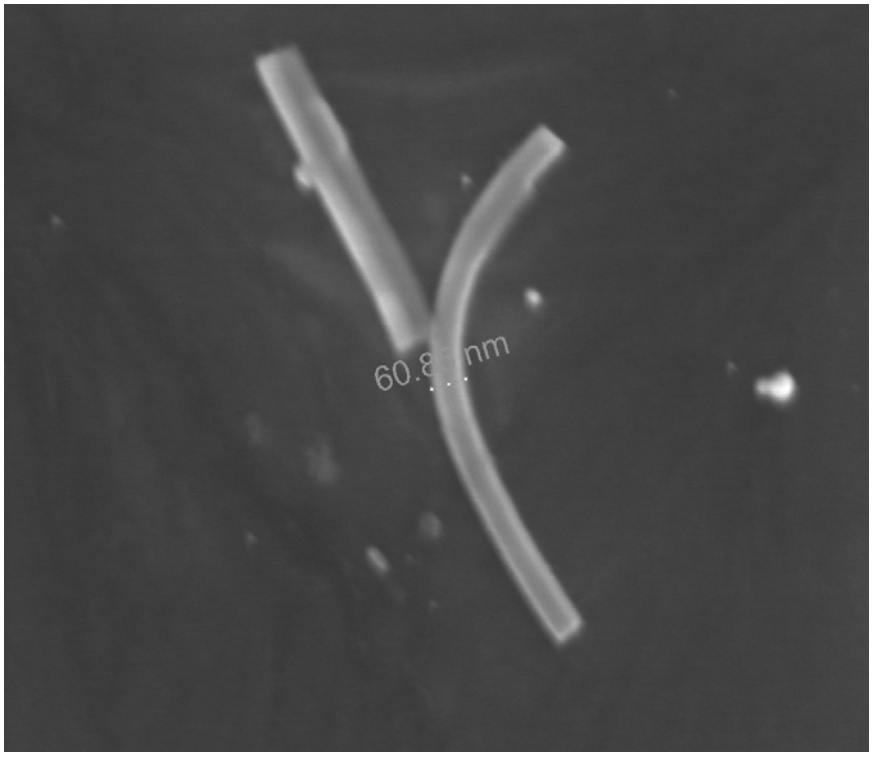
R_0 - spontaneous radius of curvature of the sheet

κ - bending modulus of the cylinder

ε - (net) cohesive free energy per unit length

Short hexagons





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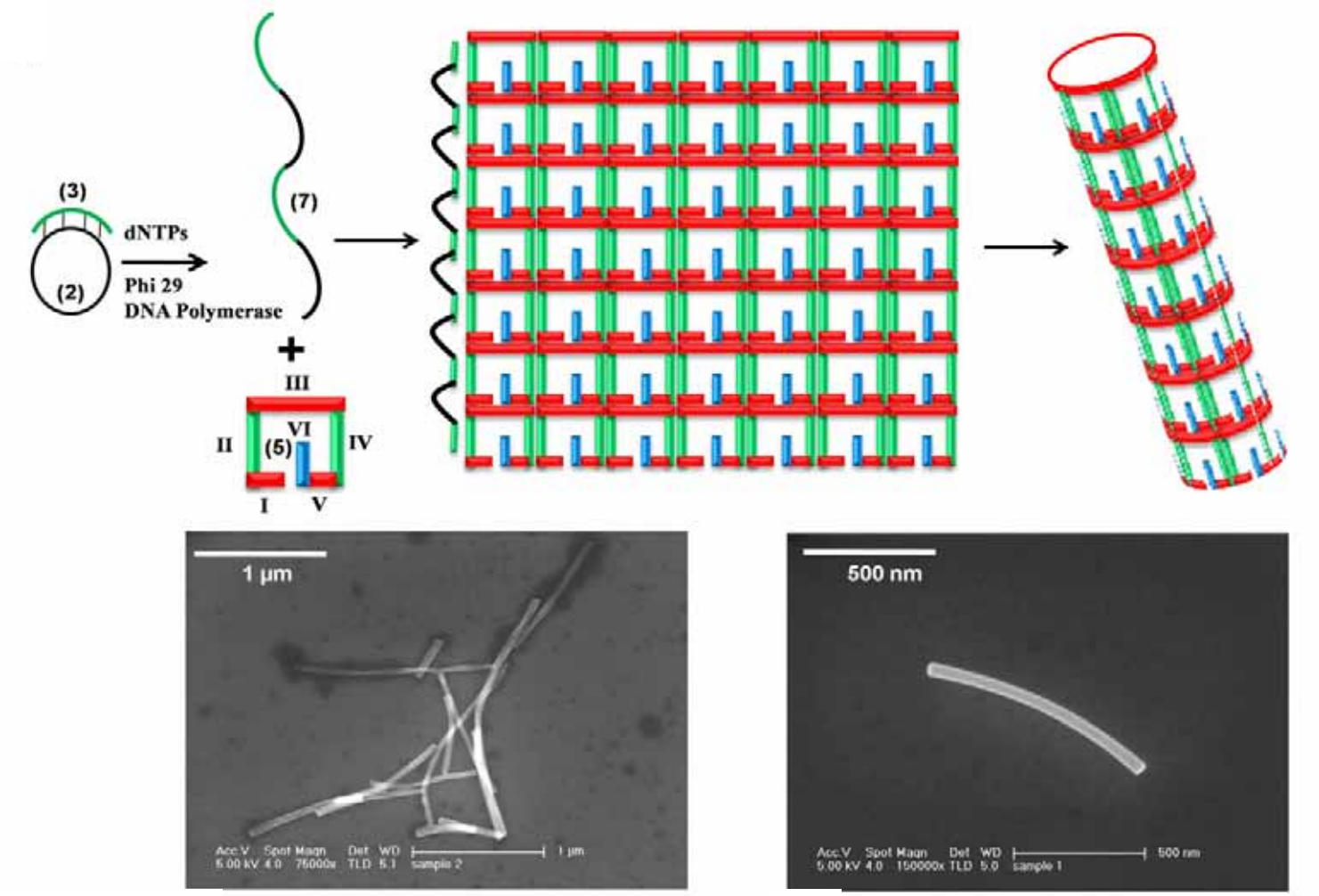
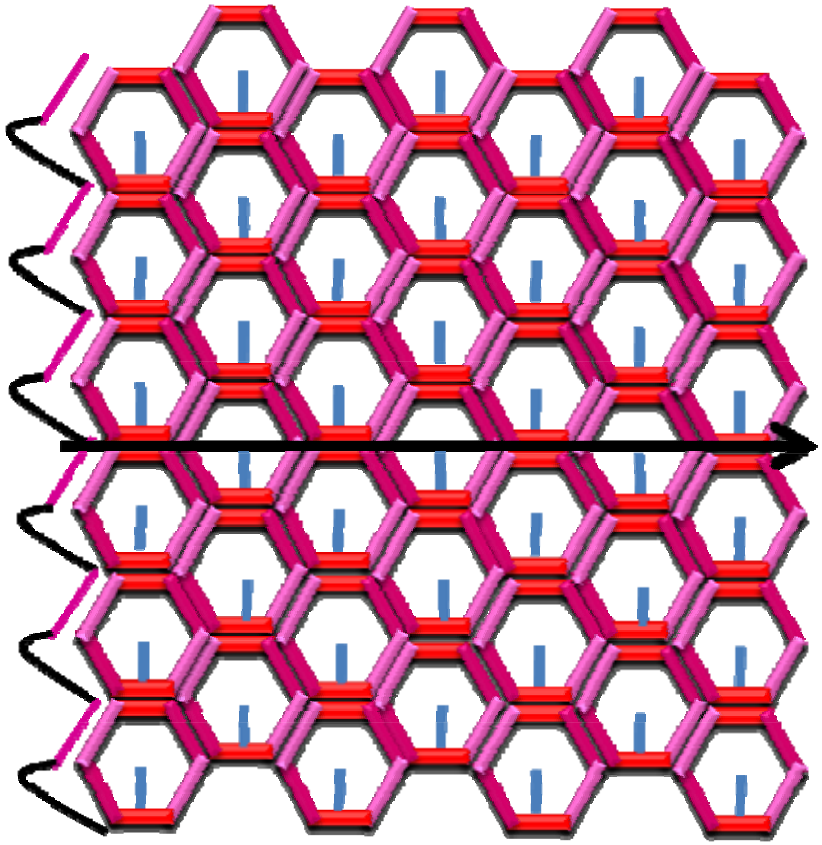
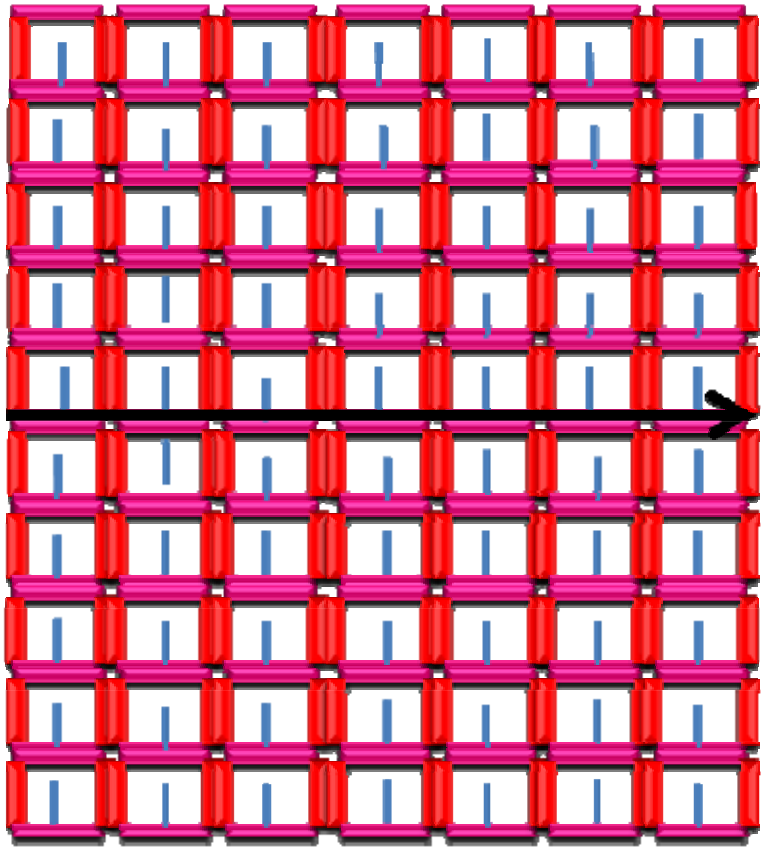
Tetragon-lattice DNA nanotubes



Nature Communications 2 (2011) 540

$$F = F_{binding} + F_{bending}$$





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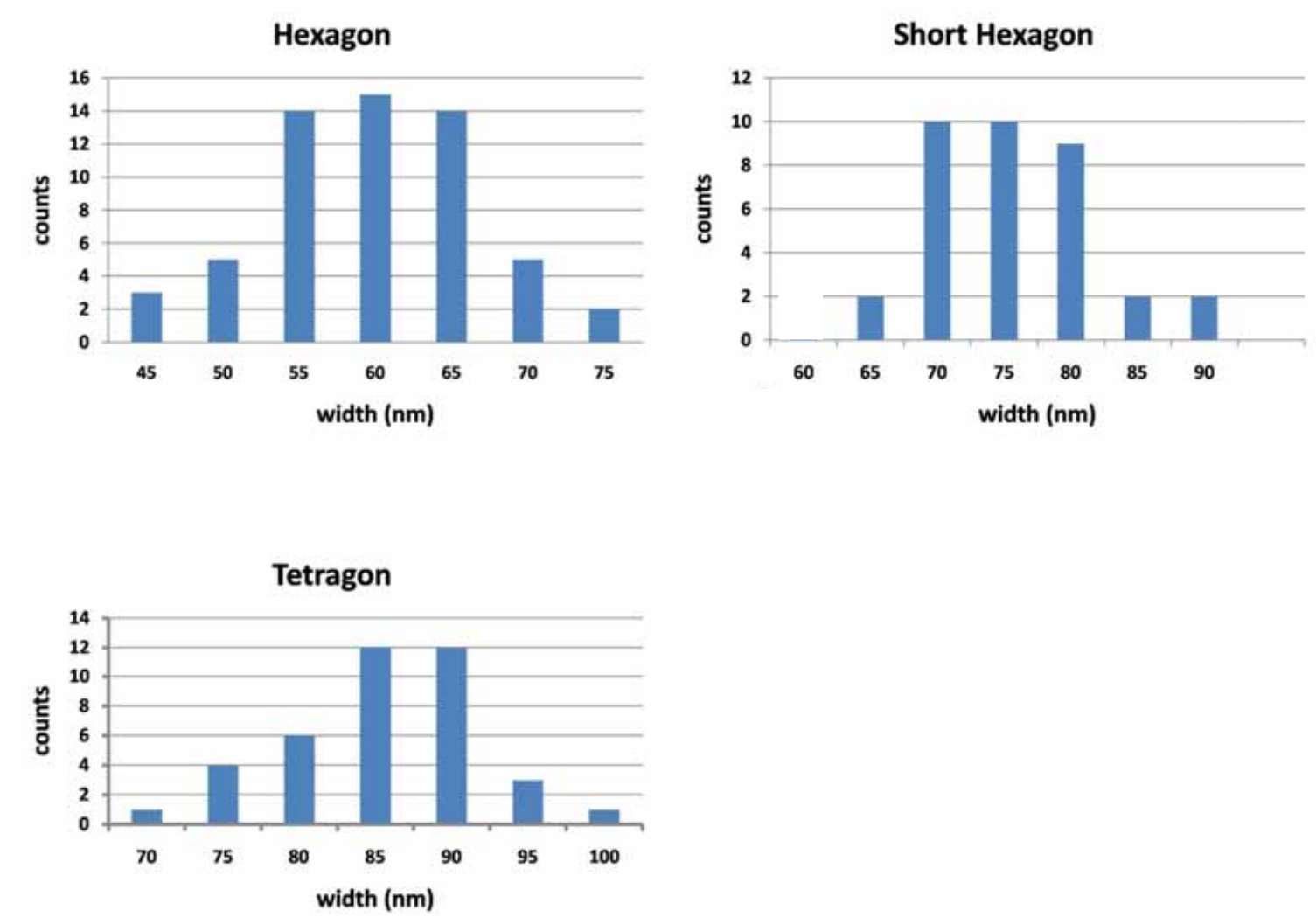
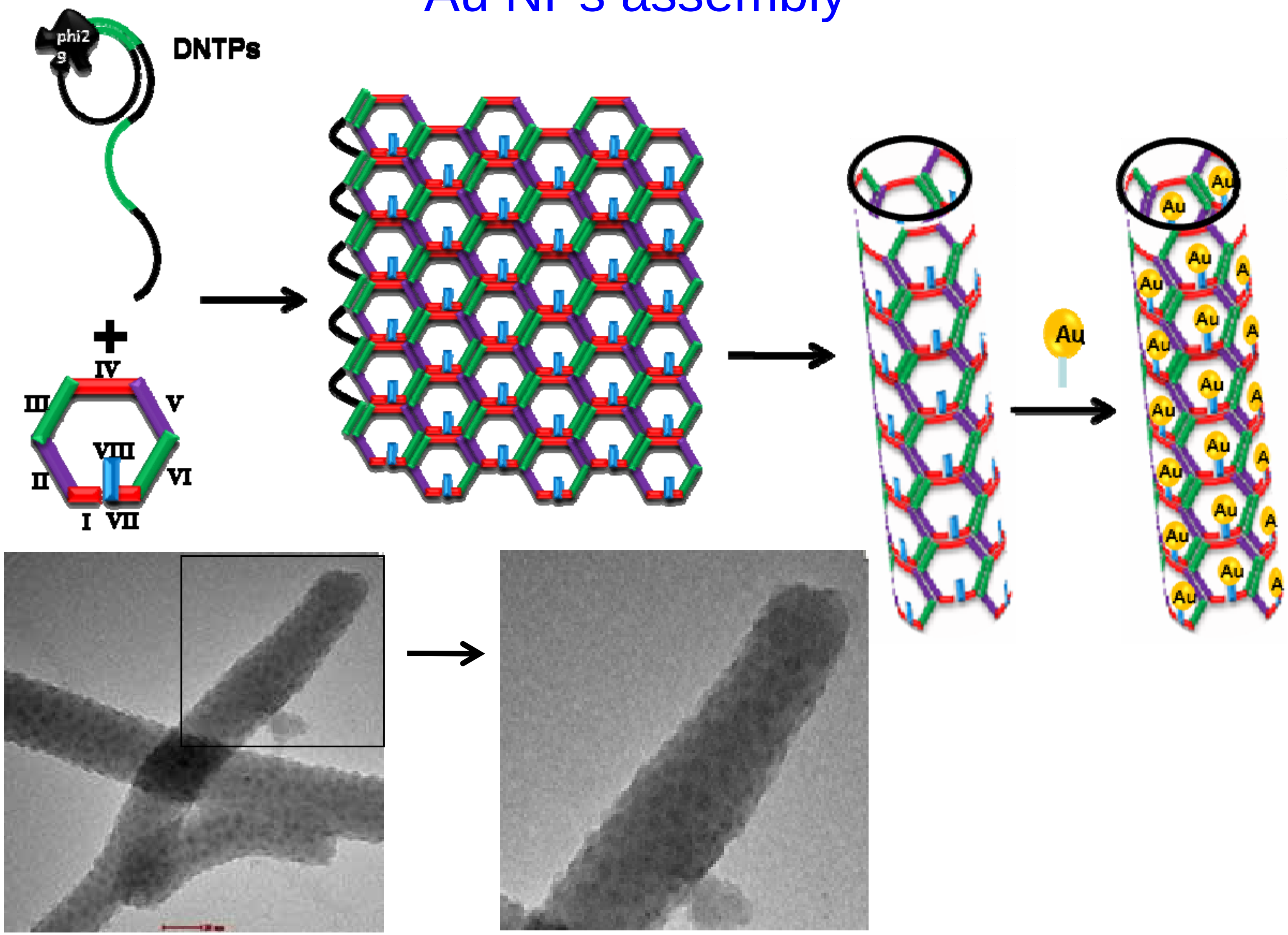
Diameter distributions of the DNA nanotubes



Au NPs assembly



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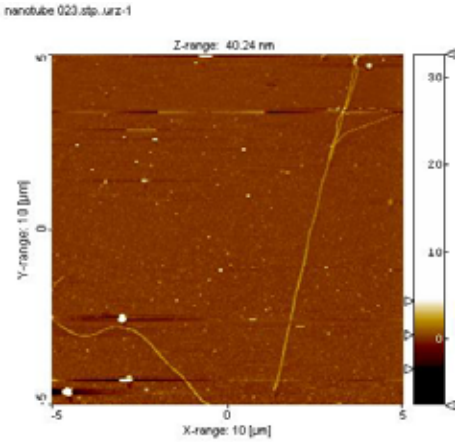
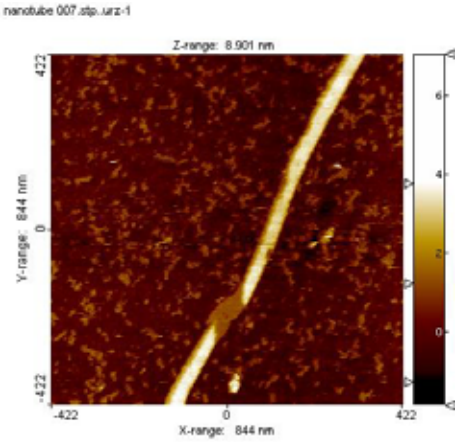
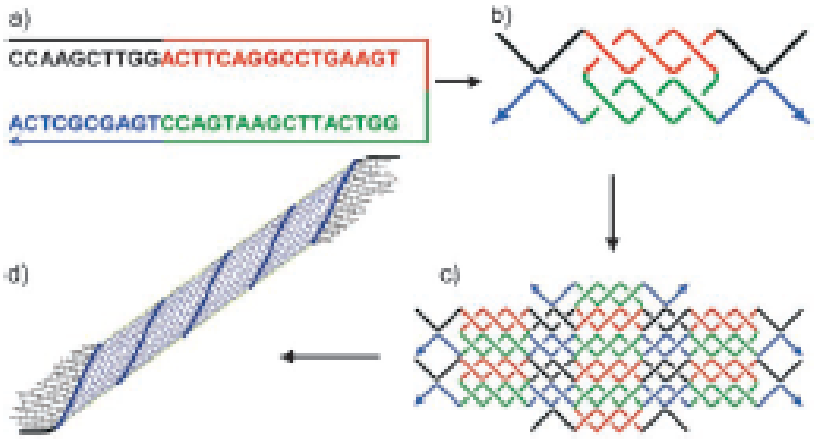
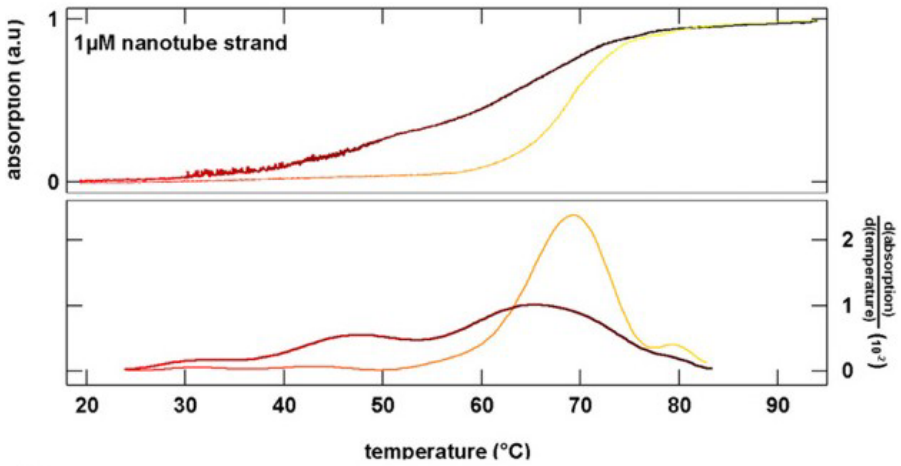
What is known so far?







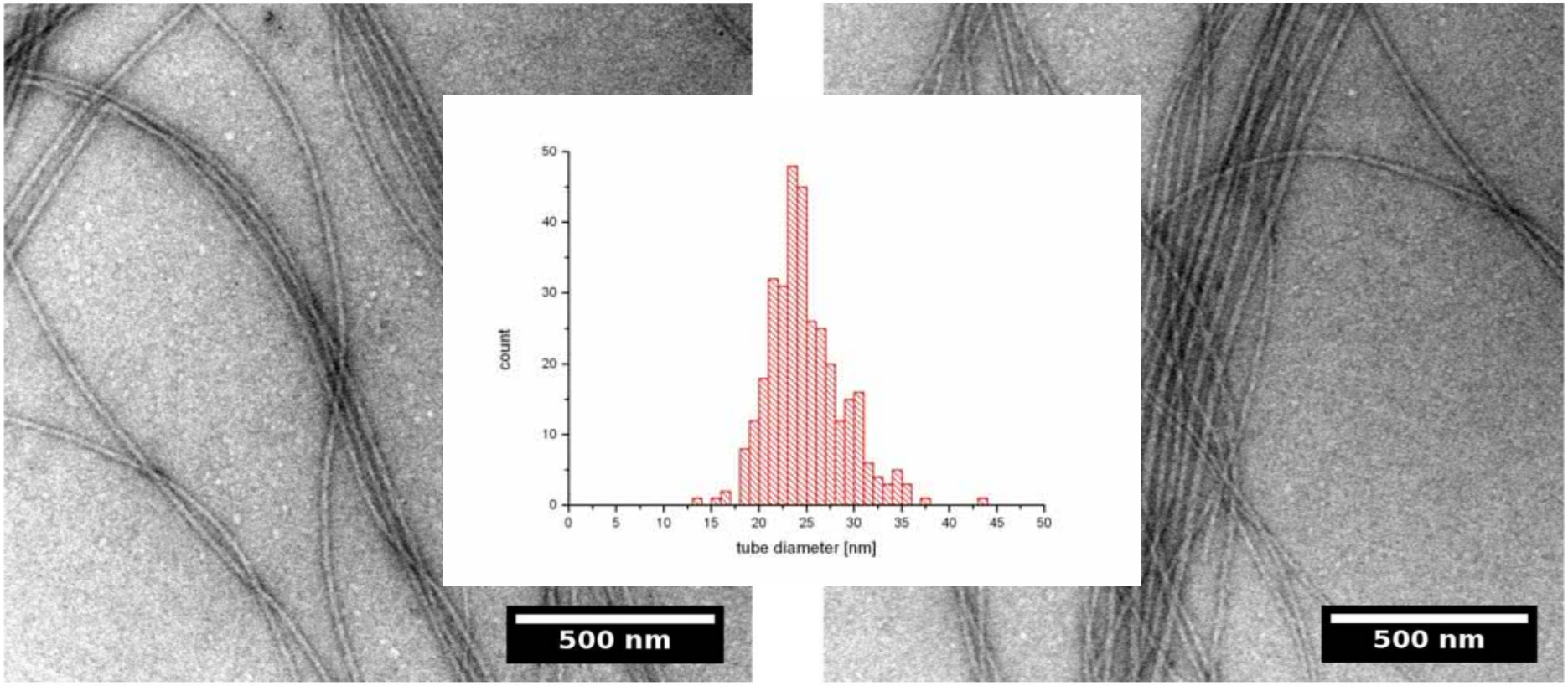
Chengde Mao design [2]



Hybridisation kinetiks [3]

C. Lin, Y. Ke, Y. Liu, M. Mertig, J. Gu, H. Yan
Functional DNA nanotube arrays: Bottom-up meets top-down
Angewandte Chemie International Edition 46, 6089 (2007)

TEM of single-stranded DNA nanotubes



Conclusions

- DNA origami nanotube
- Two different single-stranded DNA nanotubes
- Defined and narrow diameter distributions
- Mechanism 1: Intrinsic curvature
- Mechanism 2: Templating by a seed strand
- Mechanism 3: Intrinsic chirality
- Balance of bending and binding energy
- Tubular templates for organization of nanoparticles

Acknowledgements

@ TU Dresden

•Awadesh Dwivedi

•Philipp Fuchsenberger

•Nora Haufe

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•Matthew Wiens

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•Hao Yan

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•Ofer Wilner

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