

# **IUPAP Commission 6**

## **Nano in Biological Physics**

### **Working Group on Nanoscience**

**Pál Ormos**

**Biological Research Center**

**Szeged, Hungary**

# Program/Symposia

5th International Conference on Biological Physics  
-- ICBP2004 Gothenburg, Sweden --

- **Single molecule studies**
- **Nanotechnology and surface science in biology**
- **Biosensors and medical applications**
- **Charge transfer in biomolecules, and photobiology**
- **Structure and dynamics of biomolecules (Protein folding)**
- **Dynamical models of DNA**
- **Physics of subcellular structures**
- **Modelling aspects of cell biology**
- **Physics of the neural system**
- **Evolution and origin of life**
- **Complex systems in biological physics**
- **General Biological Physics/Others**

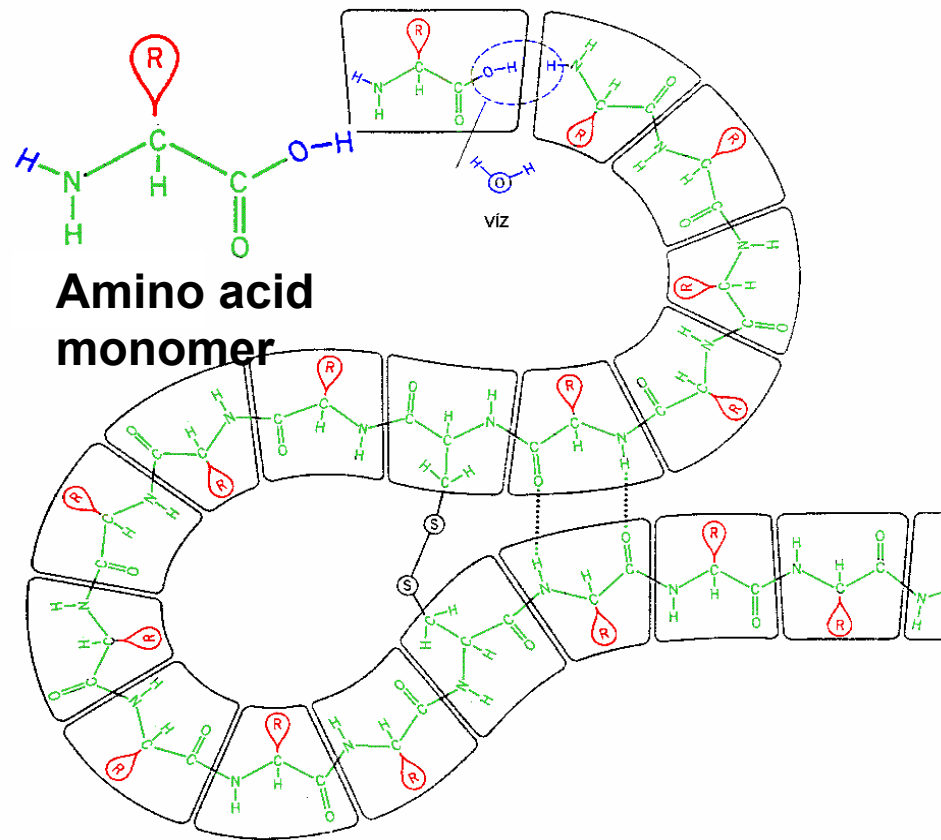
# Titles

- **Optical Explorations of Single Molecules** W. E. Moerner. *Stanford University, USA*
- **Biofunctional Supramolecular Interfacial Architectures for Optical Biosensing** Wolfgang Knoll. *MPI Mainz, Germany*
- **Single Macromolecules: Hierarchic Thermodynamics, Irreversability and Biological Function.** Kenishi Yoshikawa. *Kyoto University, Japan*
- **Single Particle Manipulation by Microstructures Generated and Operated by Light.** Pal Ormos. *Szeged University, Hungary*
- **Direct Observations of Tiers in the Energy Landscape of a Protein: A Single Molecule Study**Jürgen Köhler. *University of Bayreuth,*
- **LexA-DNA Bond Strength by Single Molecule Force Spectroscopy** Lilian T. Costa. *LM University, Munich, Germany*Break16:20-16:40
- **Single Molecule Spectroscopy with Vibronic Excitations** Andreas Zumbusch. *University of Munich, Germany*
- **Atomic-scale Dynamical Single Molecule Observations Using X-rays** AYuji C. Sasaki. *JASRI, Sayou-gun, Hyougo-ken, Japan*

# Titles

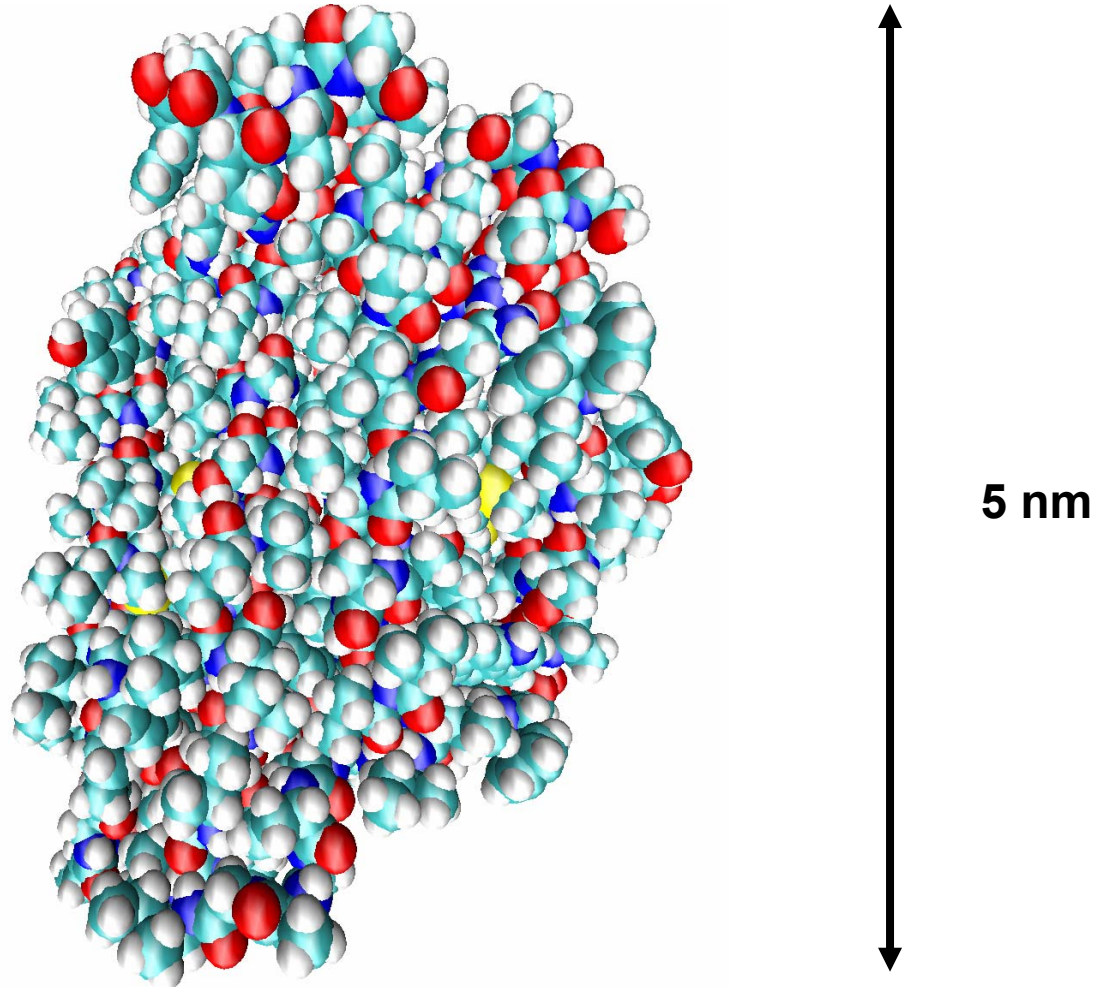
- **Ions Crossing a Viral Ion Channel: Steered Molecular Dynamics Simulations on Vpu from HIV-1** Wolfgang B. Fischer. University of Oxford, UK
- **Novel Fluorescent Proteins for Molecular and Cellular Biophysics Studies** Gerd Ulrich Nienhaus. University of Ulm, Germany
- **Bilayers in a Supporting Role: Tethered Vesicles and Composition Analysis** Steven G. Boxer. Stanford University, USA
- **Molecular Recognition in 2D Binary Mixtures of DNA-Base Molecules Studied by STM** Maya Schöck. University of Aarhus, Denmark
- **Spontaneous Stretching of DNA in Nanofluidic Channels** Jonas O. Tegenfeldt. Lund University, Sweden
- **Protein Surface – the Dynamics of the Interactions between Protein, Water and Small Solutes** Ran Friedman. Tel Aviv University, Israel
- **Molecular Recognition Based on Optical Spectroscopy of Single Gold Nanoparticle** Gunnar Raschke. LM University, Munich, Germany
- **Target Specificity of a Peptide Aptamer Selected against Titanium** Kiyotaka Shiba. Tokyo Cancer Institute, Japan
- **Enzymatic Reactions in Biomimetic Confined Containers of Liposomes** Kristin Sott. Chalmers UT, Göteborg, Sweden

# What is a protein?



A linear chain of amino acids, the length is typically several hundred units

# What is a protein?



It has a well defined structure, can perform most complex functions

# Characteristics of „nano”

The object of biological studies is often by nature of nano scale, but in general they are not regarded as nano.

Single molecule approach is by convention also called nano.

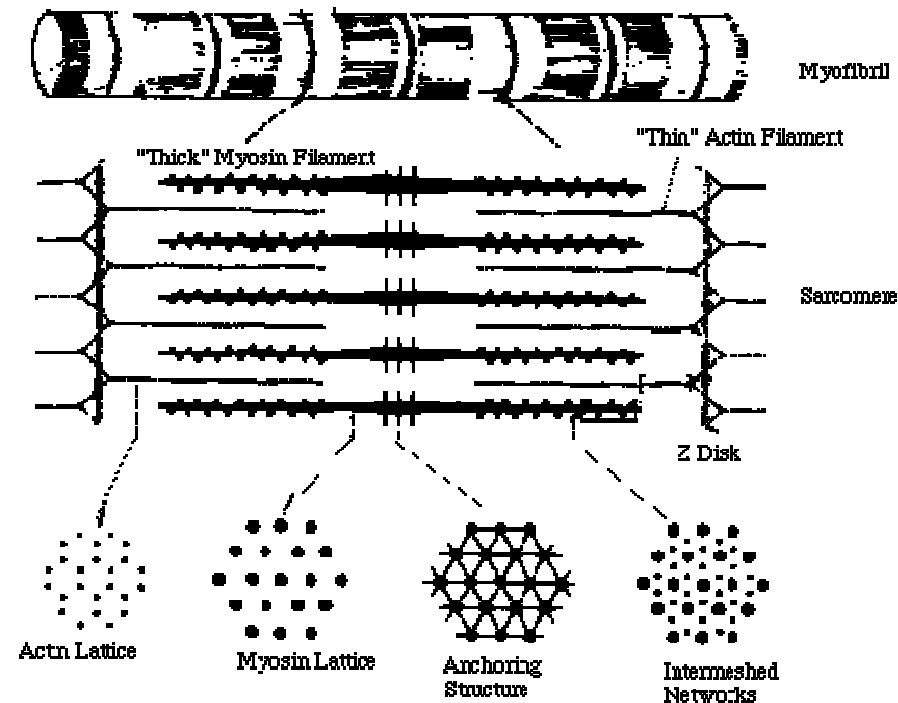
Key question:

what extra information is obtained from SMA?

Great progress lately.

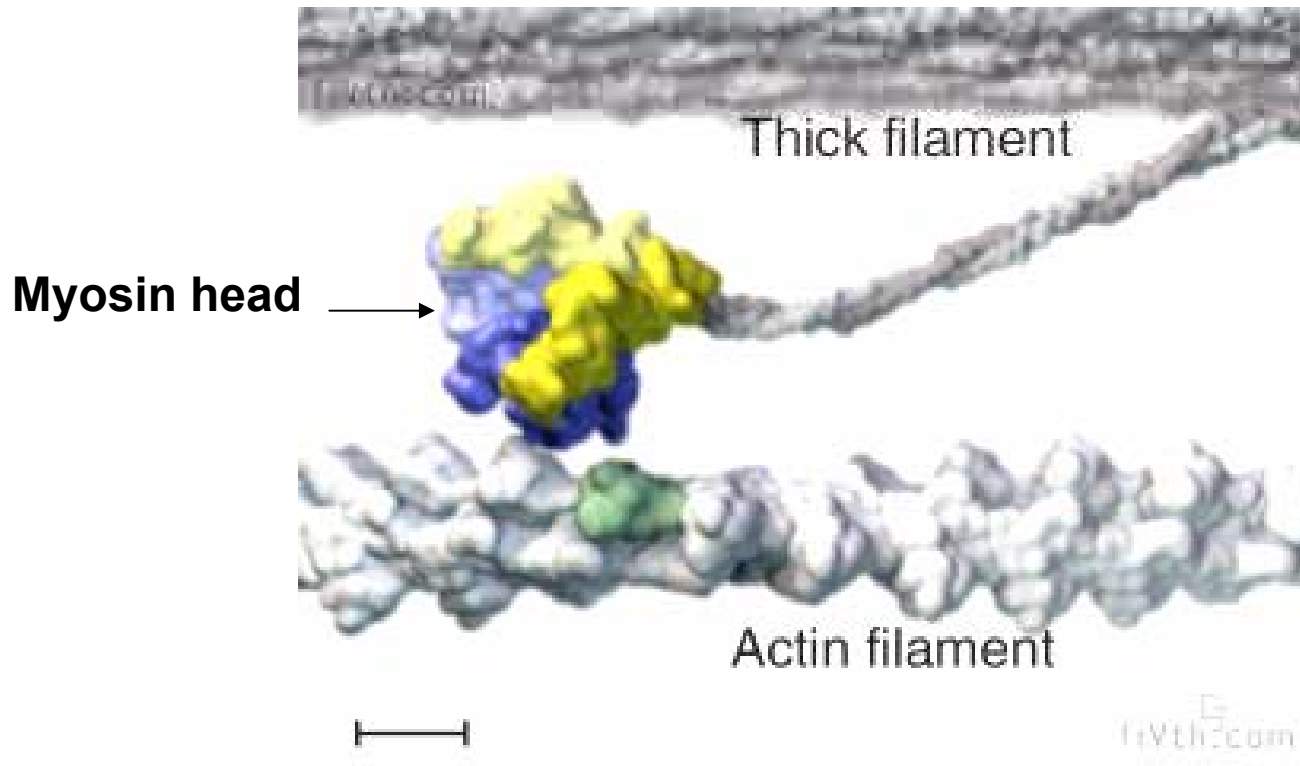
# NanoExamples in Biology: Muscle

The force generating tissue



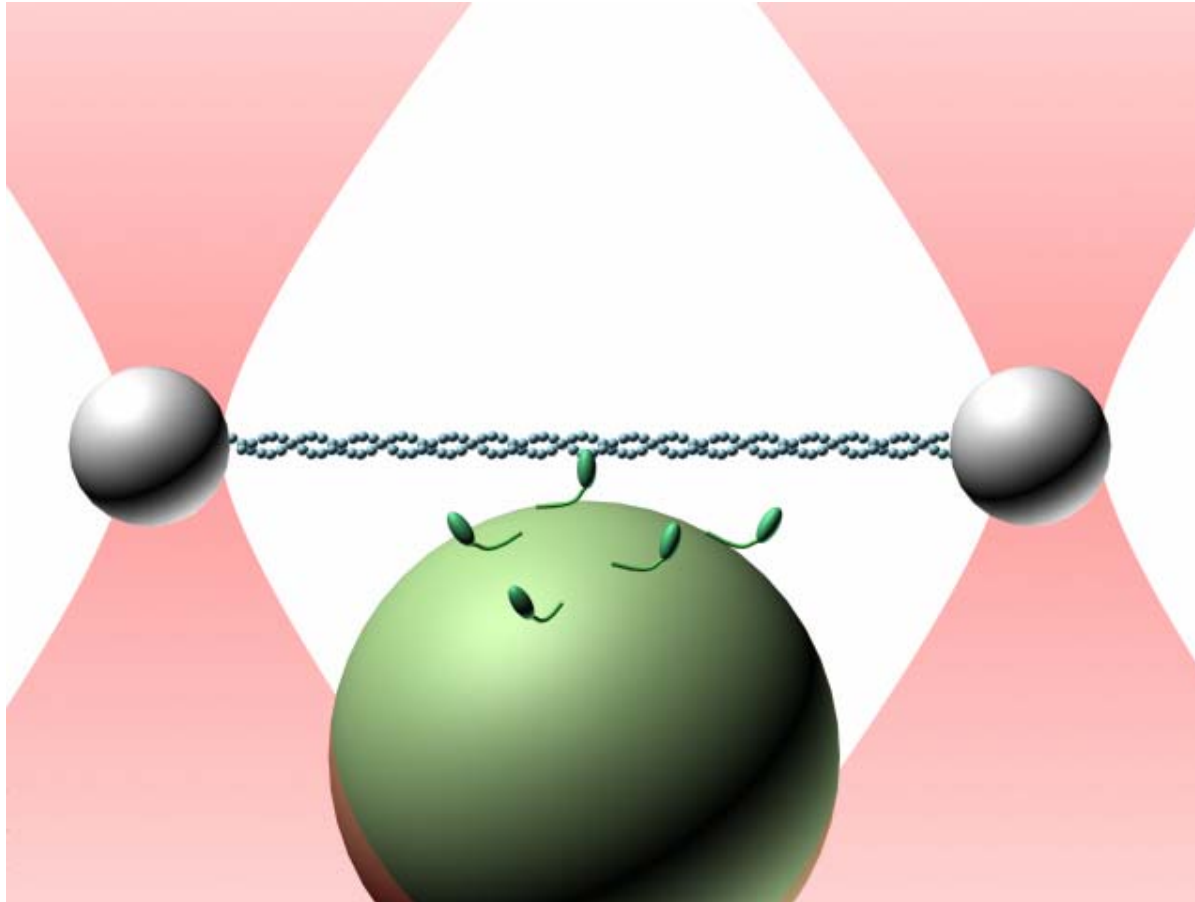


# Muscle



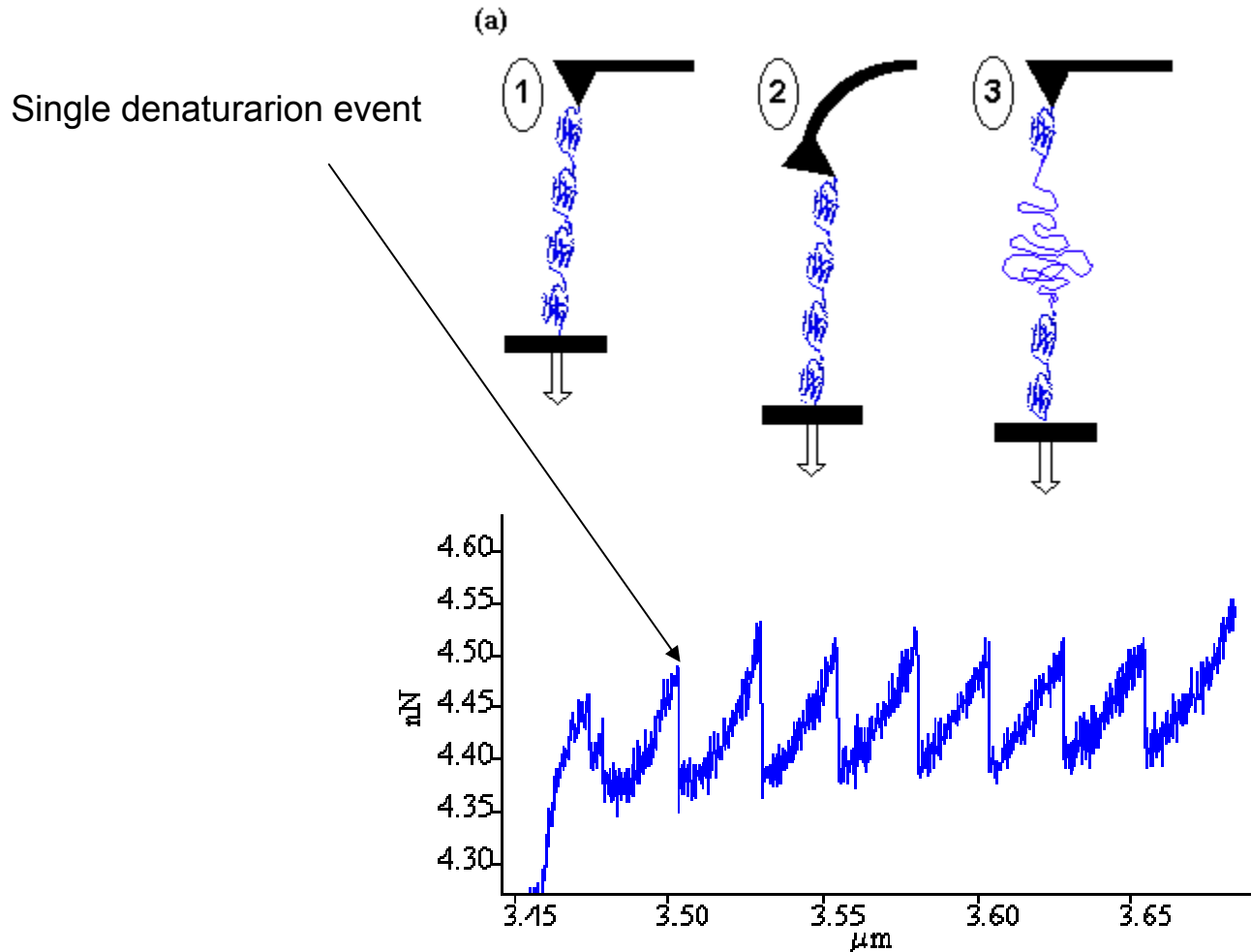
**The myosin „walks” along the actin filament**

# Muscle



**Myosin walk studied by optical tweezers**

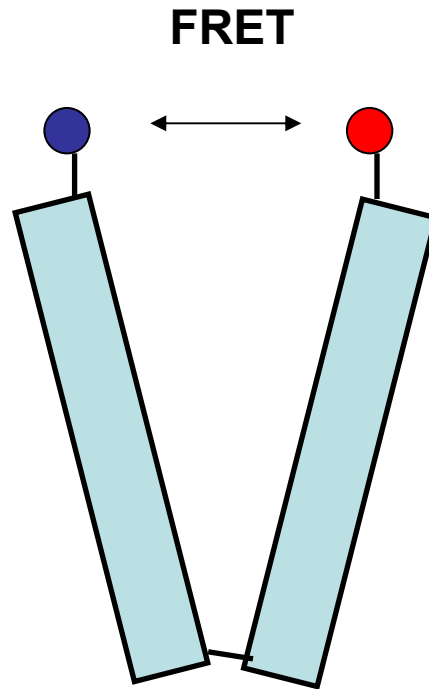
# Muscle



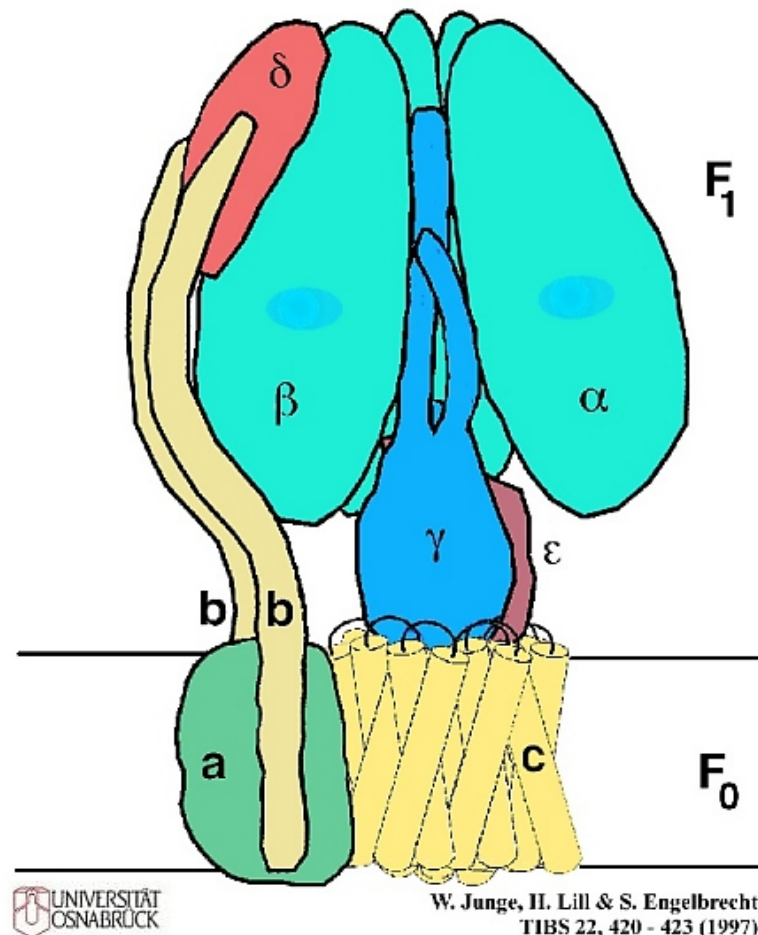
H. Gaub  
TU Munich

**The structural component titin is unfolded by mechanical force**  
**Single unfolding events are observed**

# Single protein folding

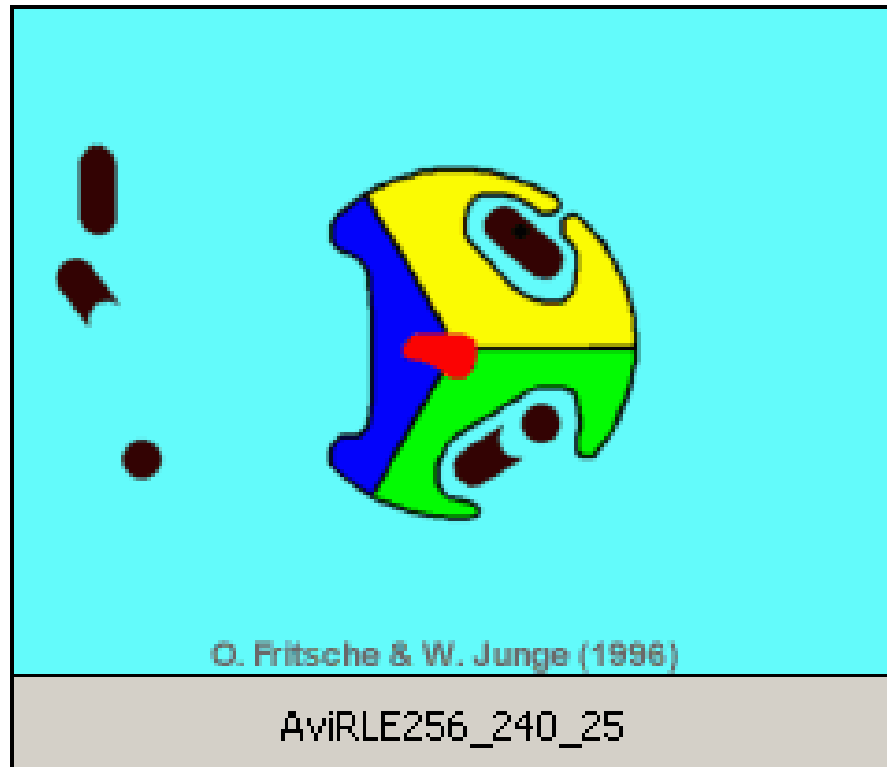


# Rotating ATPase

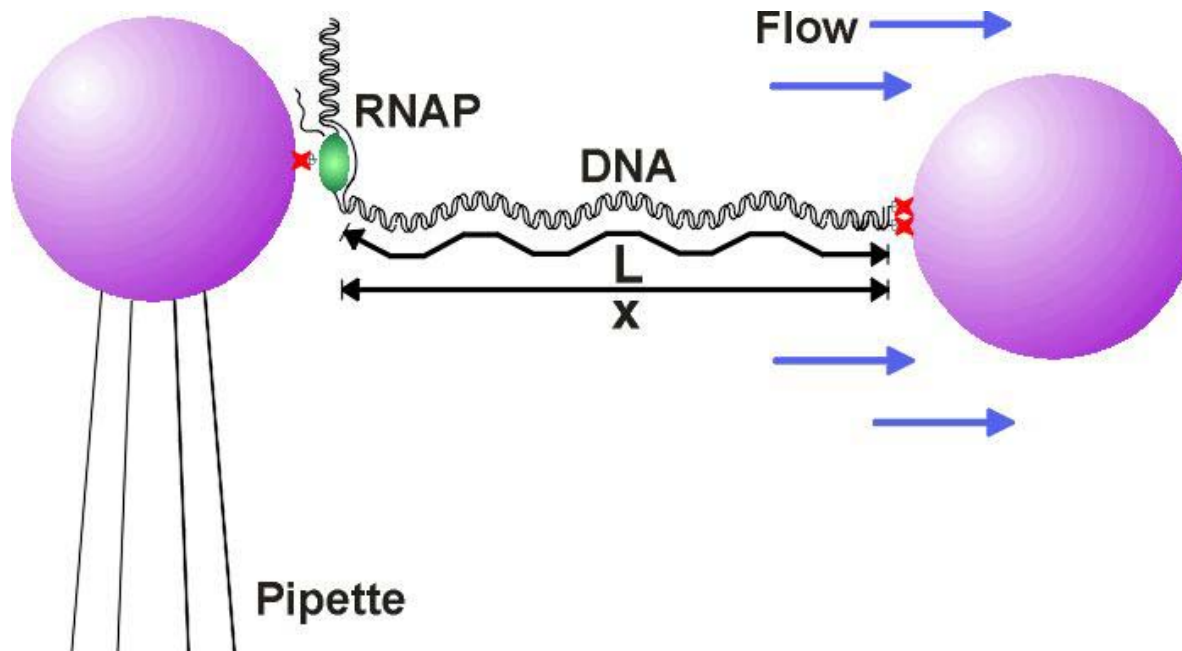


Energy from ATP hydrolysis is transported to the proton pump by rotating axle <sup>13</sup>

# Rotating ATPase

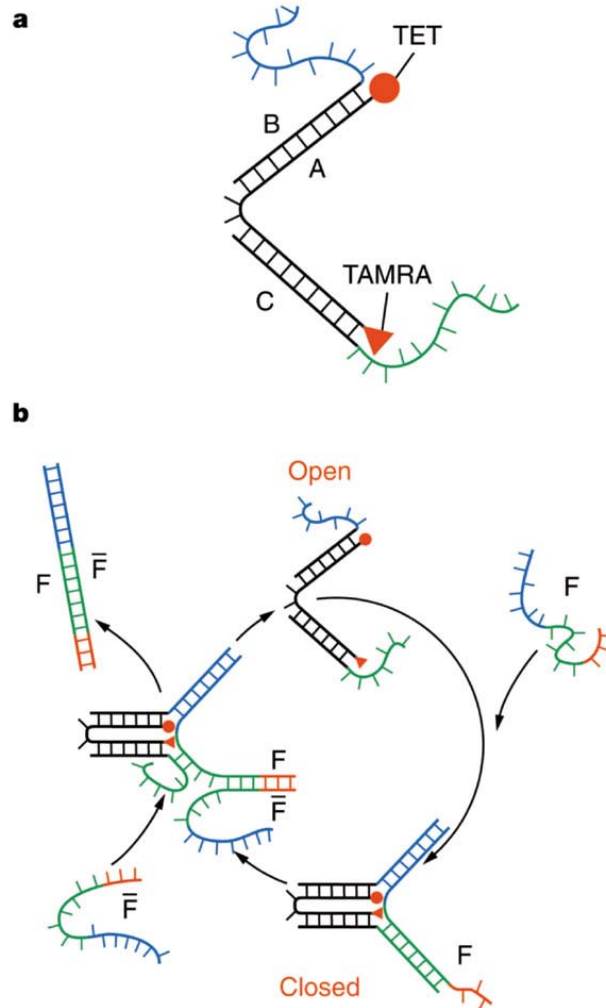


# DNA properties



**C. Bustamante, Berkeley**

# DNA mechanical engine



Yurke et al.

Bell Labs, Oxford Univ.

*Nature* **406**, 605 - 608 (2000);

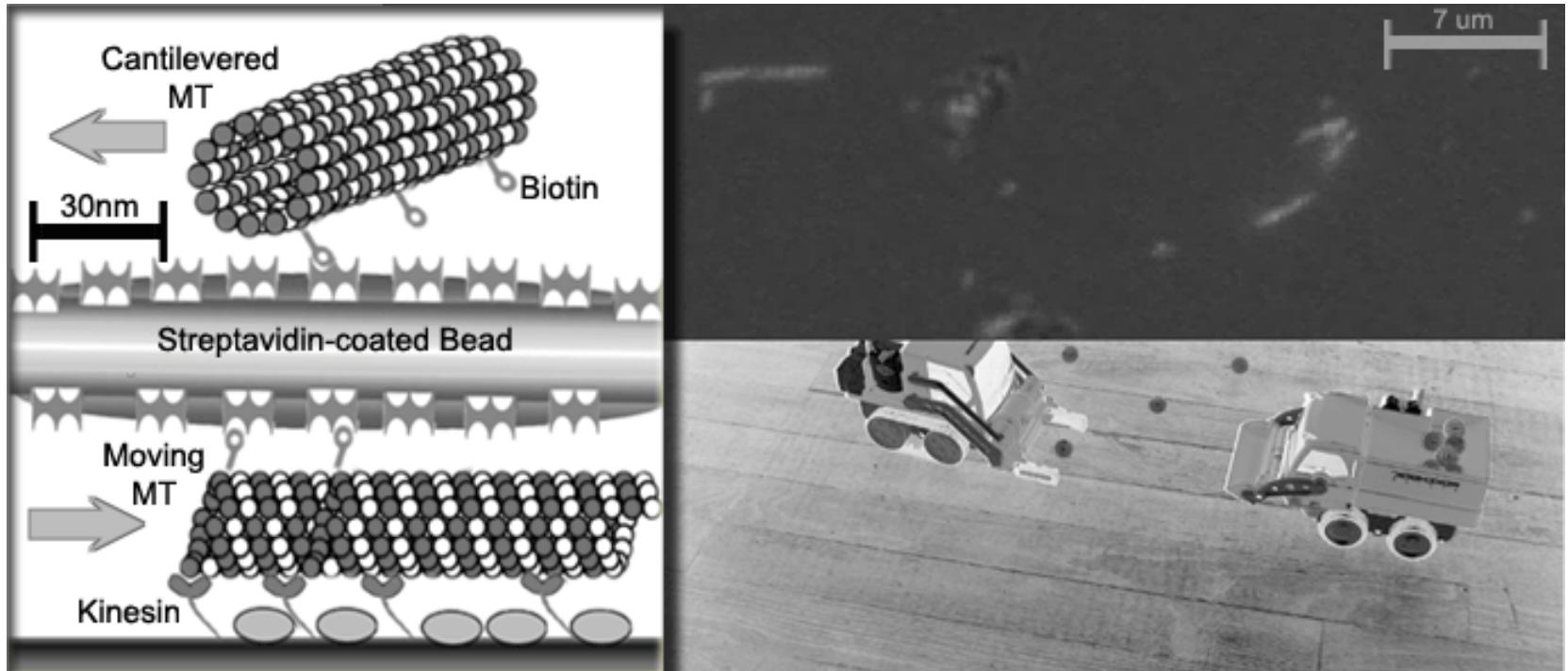


# Other areas

- Single molecule spectroscopy
- Any molecular dynamics calculation can be regarded as nano
- Biomolecules arranged on surfaces
- Matter encapsulation, membrane thethers
- etc

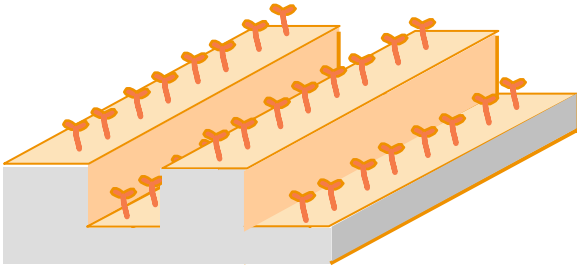
# Examples of BioNanotechnology

## Material transport with „walking” biological molecules

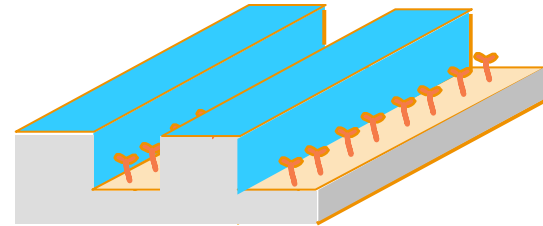


**Henry Hess,**  
Dept of Bioengineering  
Center for Nanotechnology  
University of Washington  
Seattle, WA

# Steering of material transport



**Guiding channels**



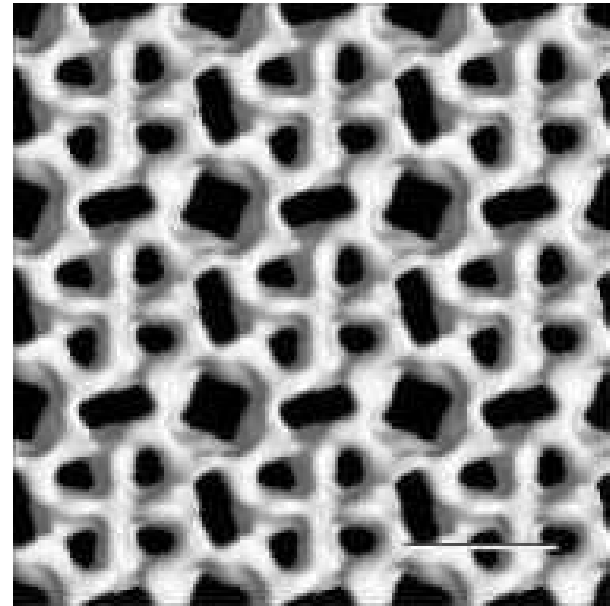
**Chemically modified channels**

J. Clemmens et al.: “Analysis of microtubule guidance by microfabricated channels coated with kinesin”, Langmuir

# Molecular filters

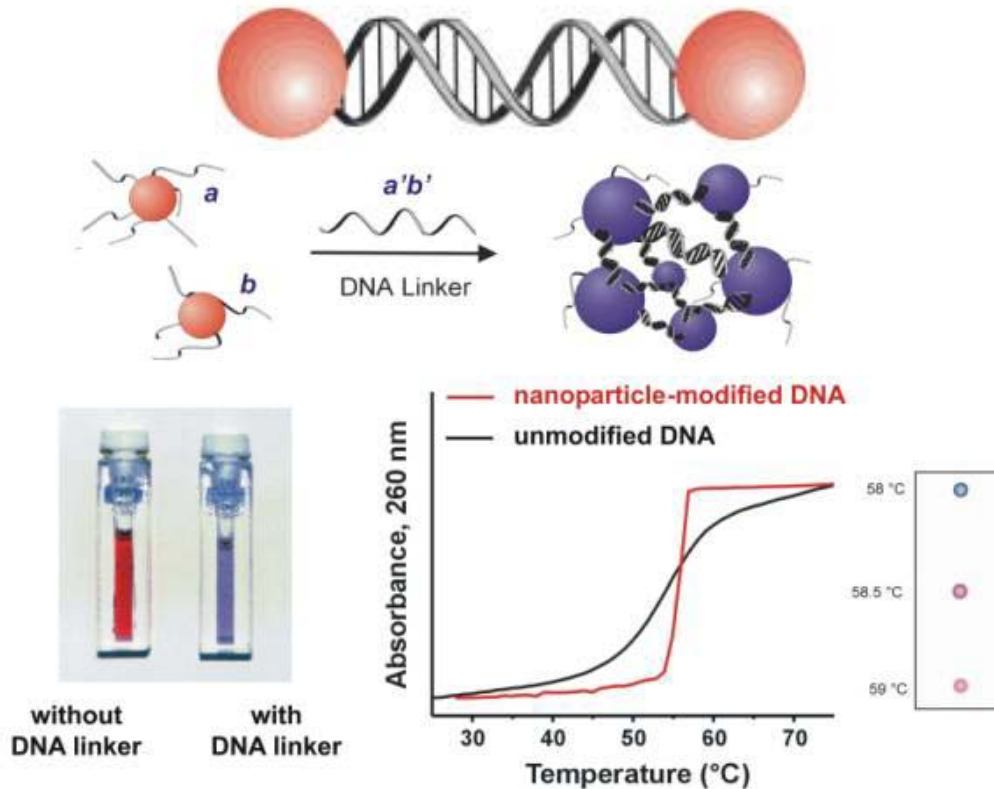


Bacterium covered with S-layer



Molecular filter built from S-layer proteins

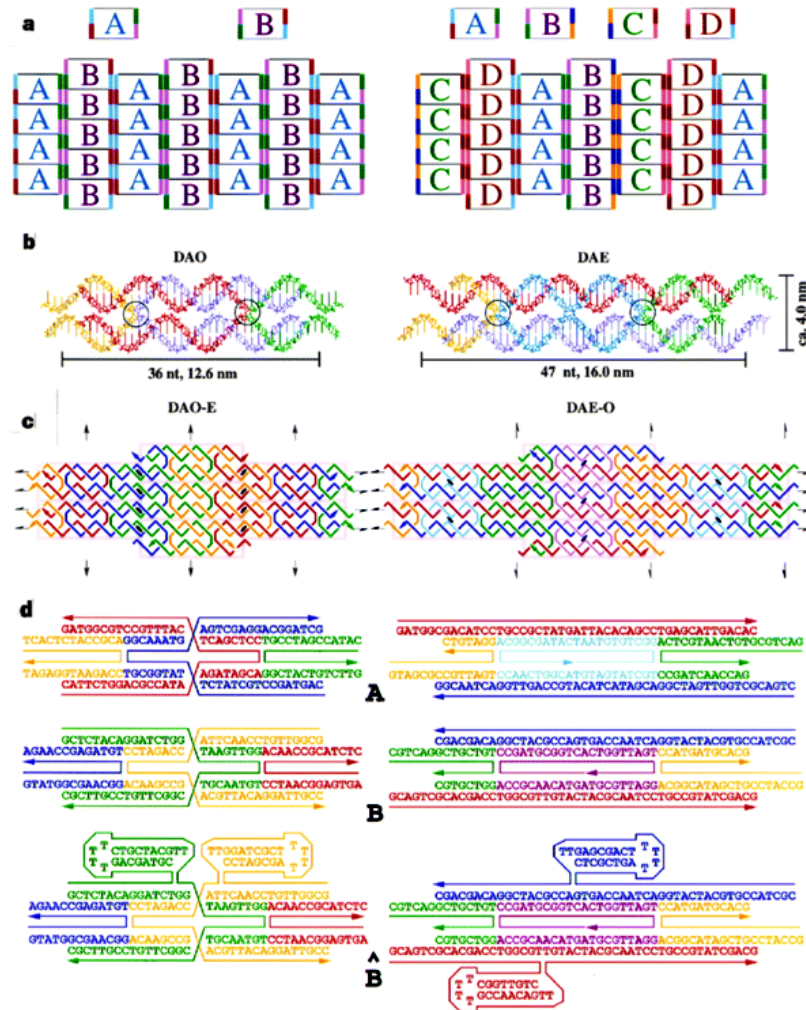
# DNA based structure building



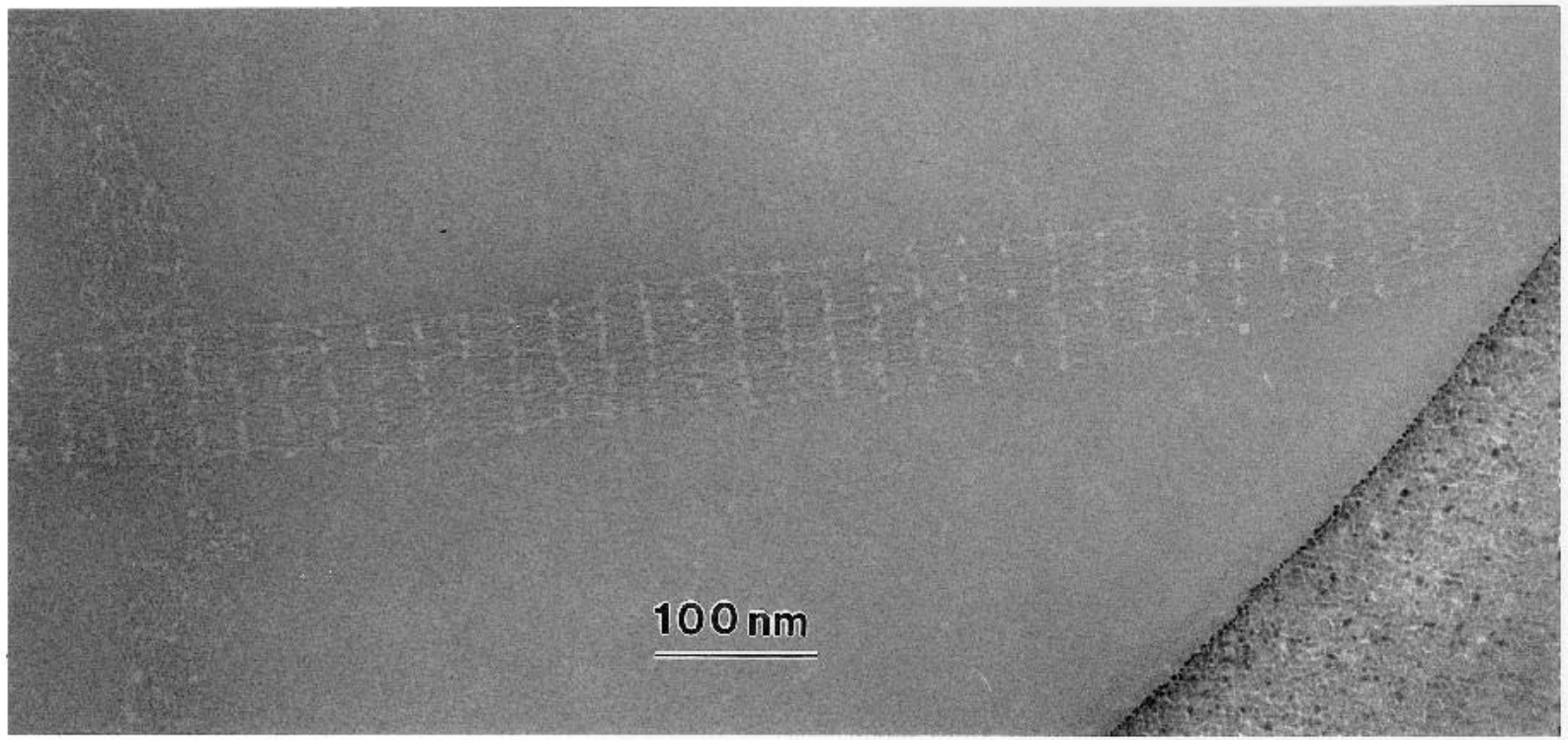
Chad Mirkin, Northwestern Univ.

DNA is a special polymer: its length and composition can be perfectly regulated

# DNA based structure building

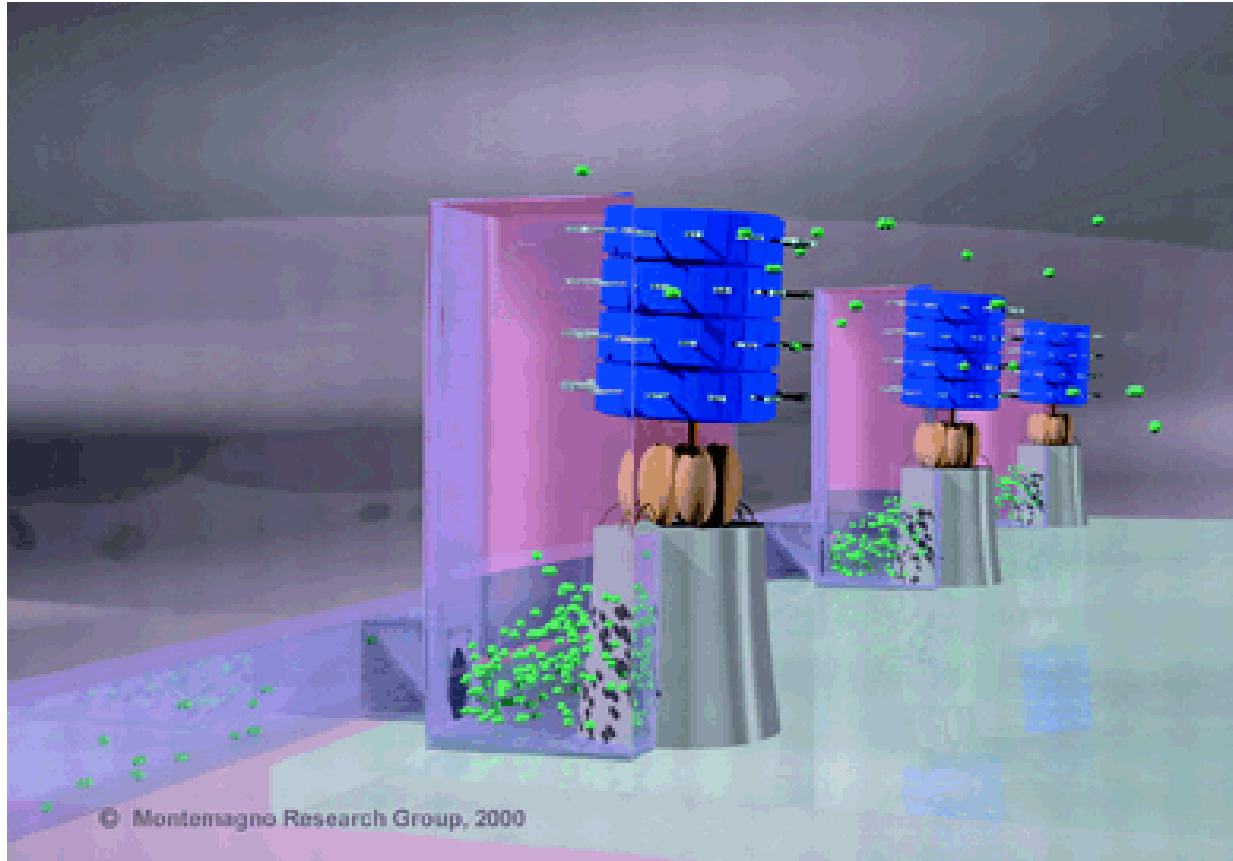


# DNA based structure building



L. Johnson, Oxford Univ.

# ATPase in technology



j. Montemagno, Cornell

**Molecular pumps driven by rotating ATPase**