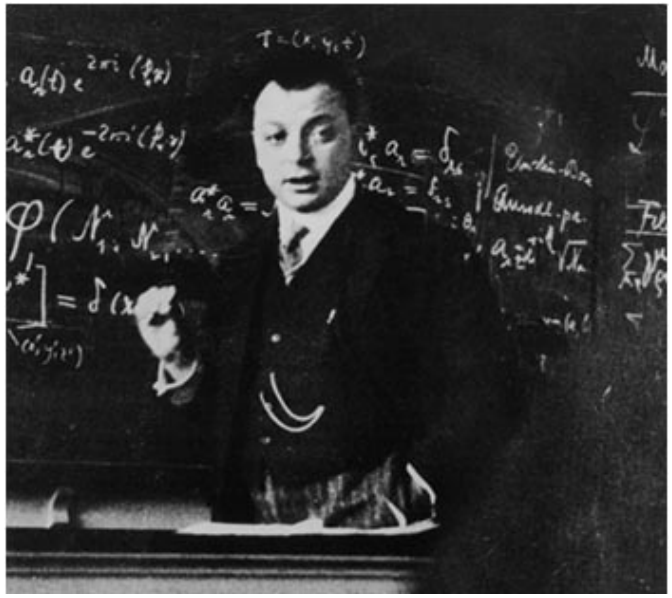
# Biological physics at UBC

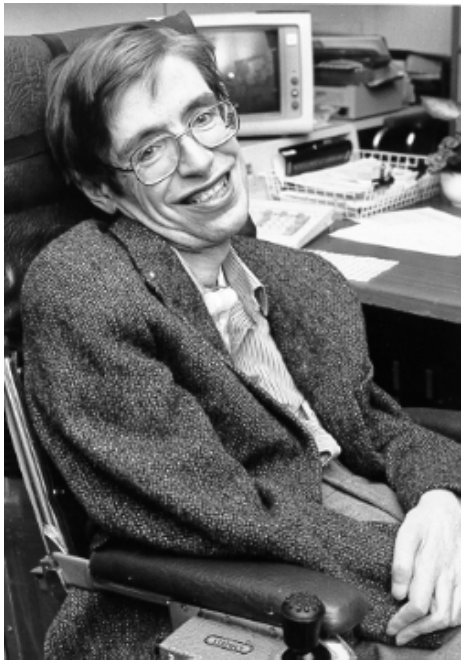
Wolfgang E. Pauli:
"Festkörperphysik ist eine Schmutzphysik."



"Condensed matter physics is the physics of dirt."

"I think the next [21st] century will be the century of complexity. We have already discovered the basic laws that govern matter and understand all the normal situations. We don't know how the laws fit together."

*To the question: Some say that while the twentieth century was the century of physics, we are now entering the century of biology. What do you think of this?*



The mathematician says:

$$\lim_{x \to 8} \frac{1}{x - 8} = \infty$$

- Quantitative tools (analytical and computational) are necessary for solutions, bio is becoming more quantitative.

- "Any scientist of any age who wants to make important discoveries must study important problems... It is not enough that a problem should be interesting."

  -Sir Peter Medawar, Nobel Laureate, "Advice to a Young Scientist"

The mathematician says:

$$\lim_{x \to 8} \frac{1}{x-8} = \infty$$

The biologist interprets:

$$\lim_{x \to 5} \frac{1}{x-5} = \quad \mathbf{5}$$

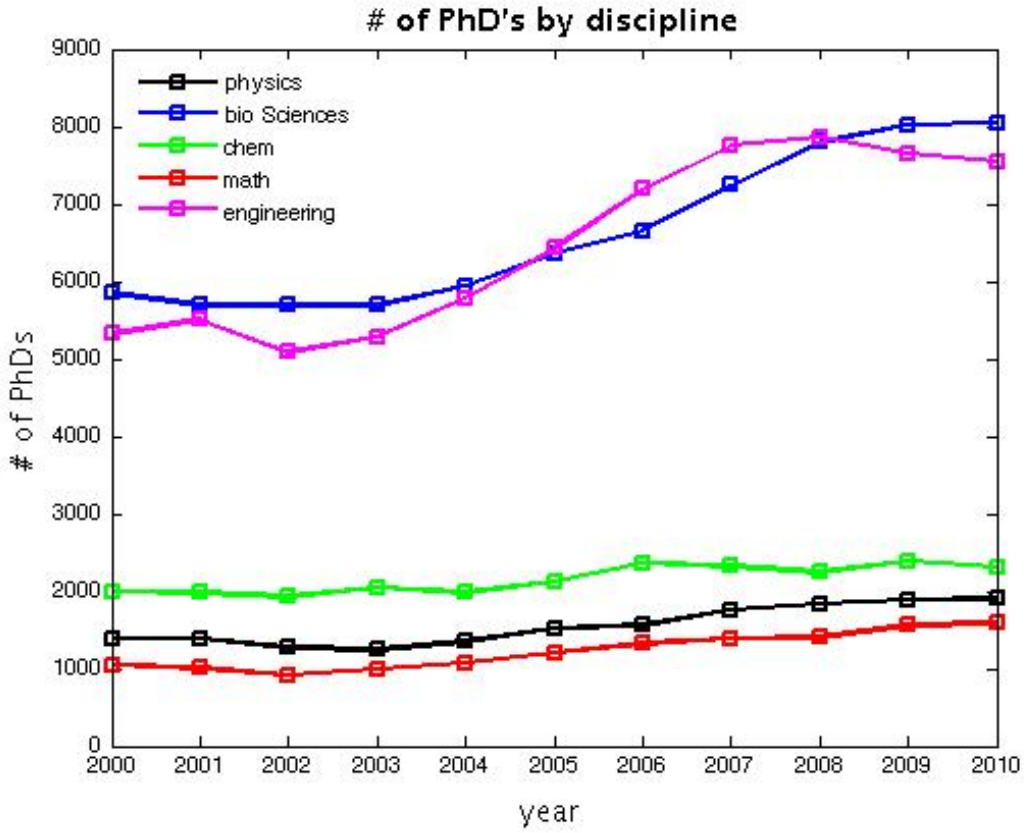
- Quantitative tools (analytical and computational) are necessary for solutions, bio is becoming more quantitative.

- "Any scientist of any age who wants to make important discoveries must study important problems... It is not enough that a problem should be interesting."

  -Sir Peter Medawar, Nobel Laureate, "Advice to a Young Scientist"

# Why study biophysics?

- Significant and growing interest in the field. BPS attendance now over 7000.
- Active and relatively new area of research (new questions) with much opportunity. Many new questions…




NSF data

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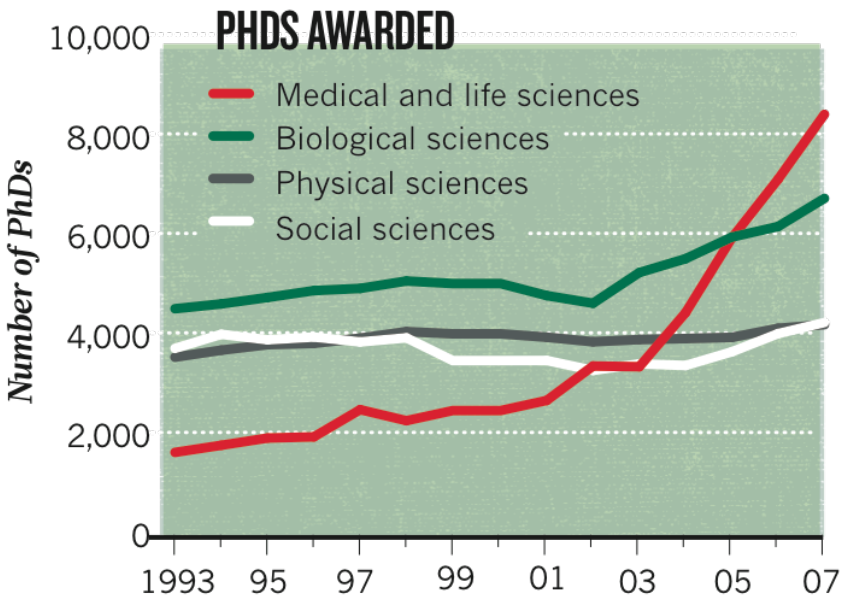


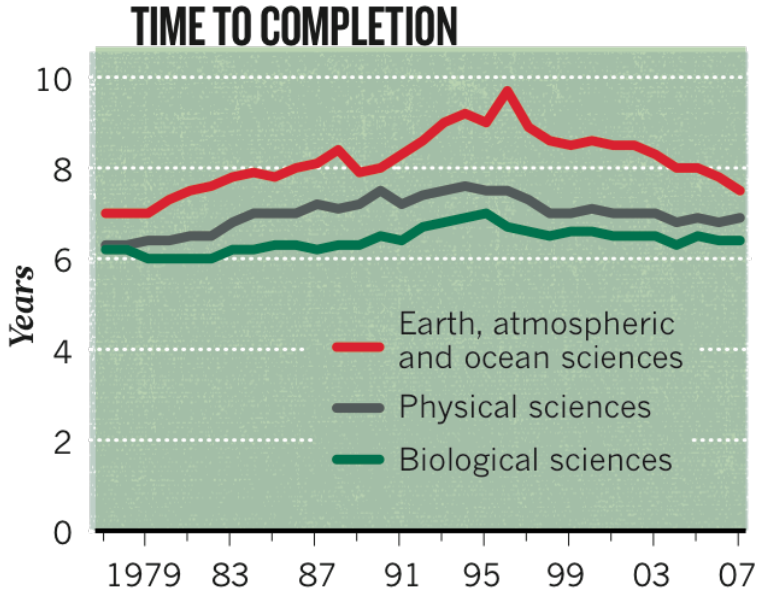

# Why study biophysics?

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**Number of jobs (2010)**

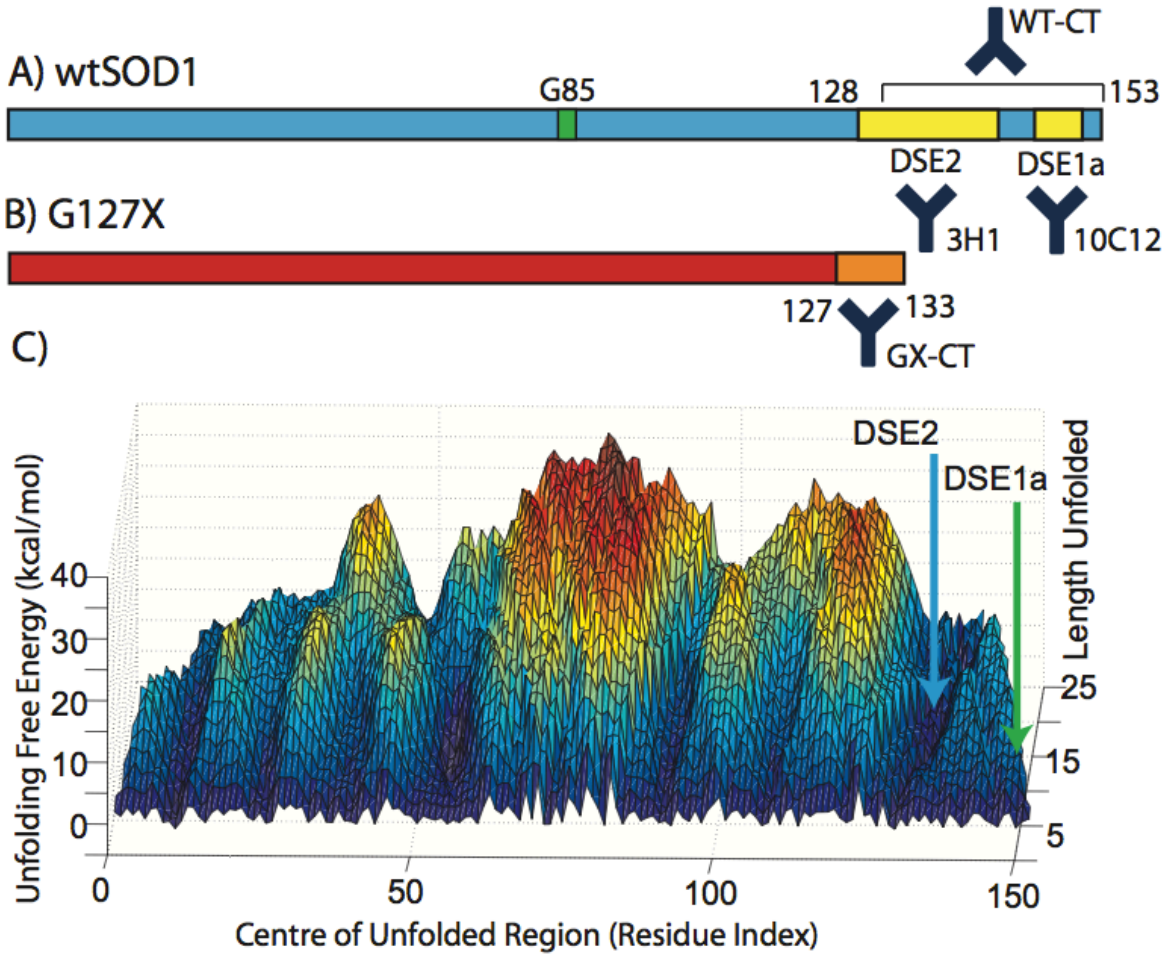
Physics, astronomy, physical sciences: 20,600
Biophysics, biochemists, medical scientist, microbiologist: 145,400

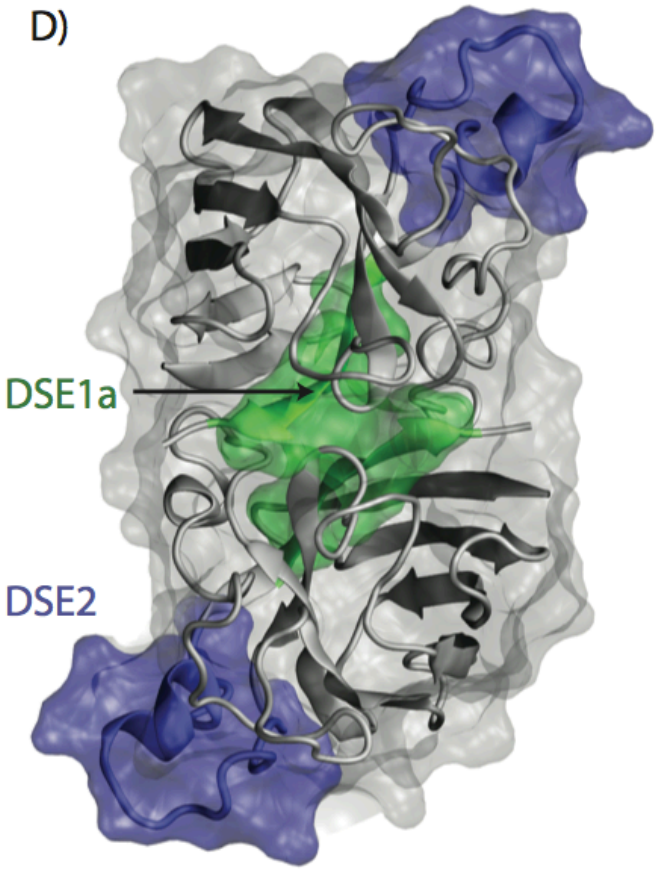
**Job outlook (projected rate of change in employment for the 10-year timeframe between 2012 and 2022)**

Physics & Astronomy: 10% (about average over all occupations)
Biophysics & Biochemists: 19% (Significantly faster than average)

(source: occupational outlook handbook: http://www.bls.gov/ooh )

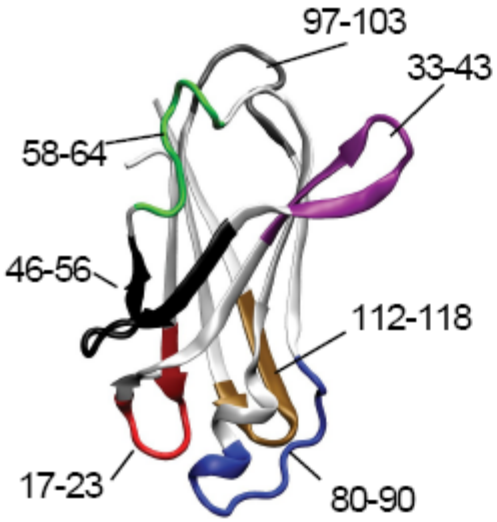
# Application of misfolding landscapes to predict disease-specific epitopes in SOD1



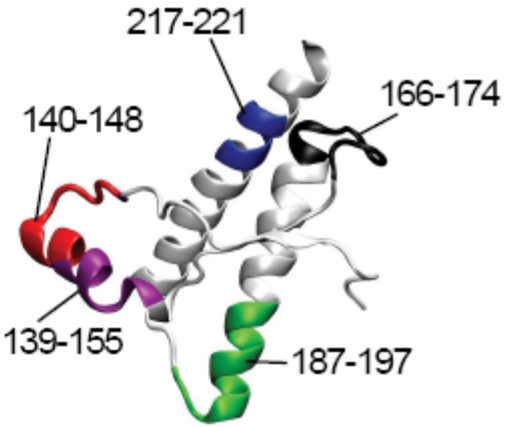



## Plotkin group

Transthyretin

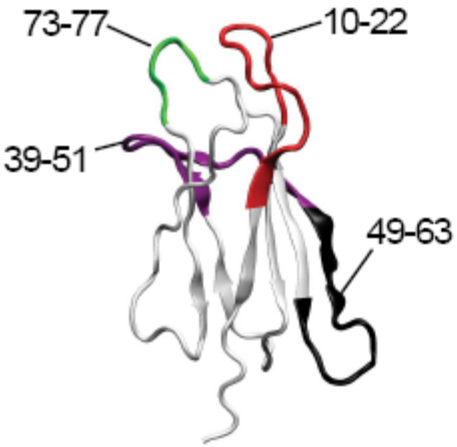



Bovine Prion Protein

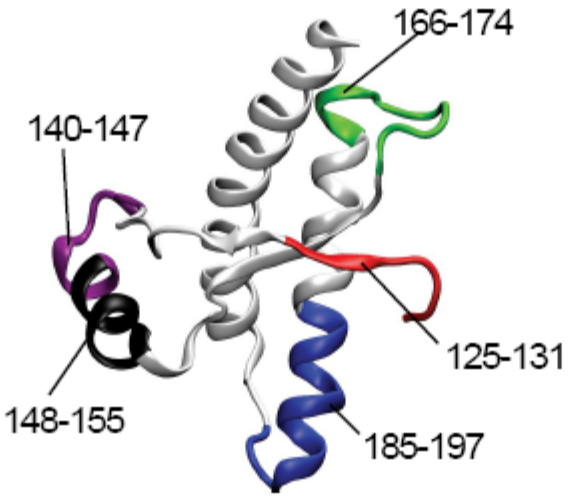



# Candidate therapeutic epitopes for protein misfolding diseases

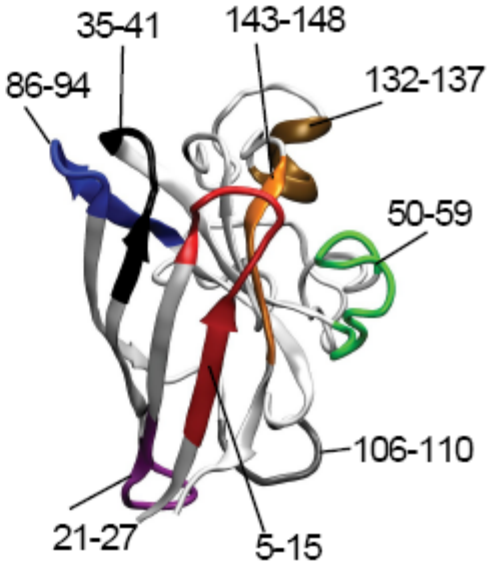
Beta 2 Microglobulin




Human Prion Protein




Superoxide Dismutase 1



# Plotkin group

PHYSICAL REVIEW D, VOLUME 00,

## Statistical mechanics of graph models and their implications for emergent spacetime manifolds

Si Chen and Steven S. Plotkin

*Department of Physics and Astronomy, University of British Columbia, Vancouver, Canada V6T 1Z1*

(Received 11 October 2012)

Inspired by "quantum graphity" models for spacetime, a statistical model of graphs is proposed to

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## Polymer Uncrossing and Knotting in Protein Folding, and Their Role in Minimal Folding Pathways

**Ali R. Mohazab, Steven S. Plotkin***

Department of Physics and Astronomy, University of British Columbia, Vancouver, B.C, Canada



## Generalization of distance to higher dimensional objects

**Steven S. Plotkin†**

Department of Physics and Astronomy, University of British Columbia, 6224 Agricultural Road, Vancouver, BC, Canada V6T 1Z1

## Plotkin group

# Quantizing models of (2+1)-dimensional gravity on non-orientable manifolds

**Si Chen, Donald M Witt and Steven S Plotkin**

Department of Physics and Astronomy, University of British Columbia, Agricultural Road, Vancouver, V6T 1Z1, Canada

**IOP** Publishing Classical and Quantum Gravity

Class. Quantum Grav. **31** (2014) 055008 (20pp) doi:10.1088/0264-9381/31/5/055008

# Intercellular propagated misfolding of wild-type Cu/Zn superoxide dismutase occurs via exosome-dependent and -independent mechanisms

**Leslie I. Grad[a,1], Justin J. Yerbury[b,1], Bradley J. Turner[c,1], William C. Guest[a], Edward Pokrishevsky[a], Megan A. O'Neill[a], Anat Yanai[a], Judith M. Silverman[a], Rafaa Zeineddine[b], Lisa Corcoran[b], Janet R. Kumita[d], Leila M. Luheshi[d], Masoud Yousefi[a], Bradley M. Coleman[e], Andrew F. Hill[e], Steven S. Plotkin[f], Ian R. Mackenzie[g], and Neil R. Cashman[a,2]**

www.pnas.org/cgi/doi/10.1073/pnas.1312245111 PNAS Early Edition | 1 of 6

# Density Functional Theory for Protein Transfer Free Energy

Eric A. Mills and Steven S. Plotkin*

Department of Physics & Astronomy, University of British Columbia, Vancouver, British Columbia V6T1Z4, Canada

THE JOURNAL OF PHYSICAL CHEMISTRY B Article

pubs.acs.org/JPCB





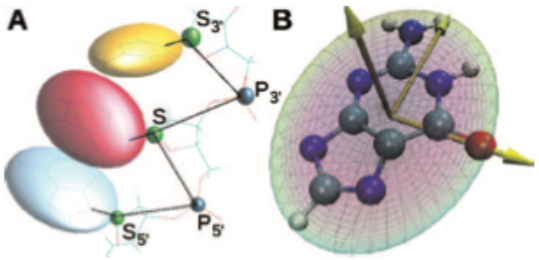
dx.doi.org/10.1021/jp403600q | J. Phys. Chem. B 2013, 117, 13278–13290

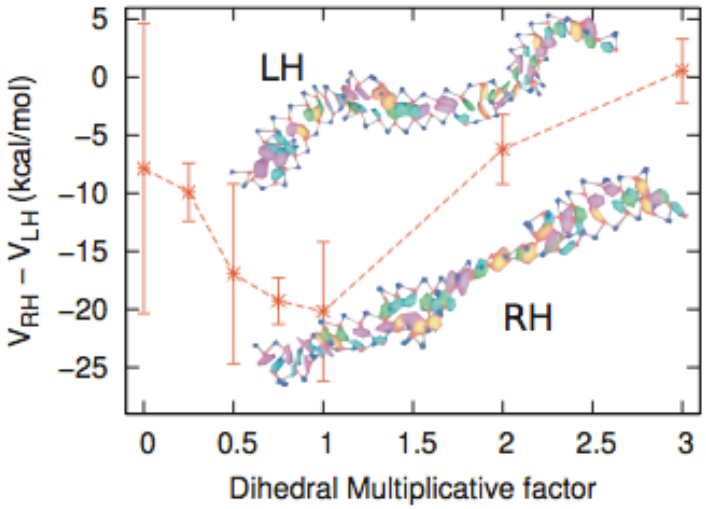
## Plotkin and Rottler groups

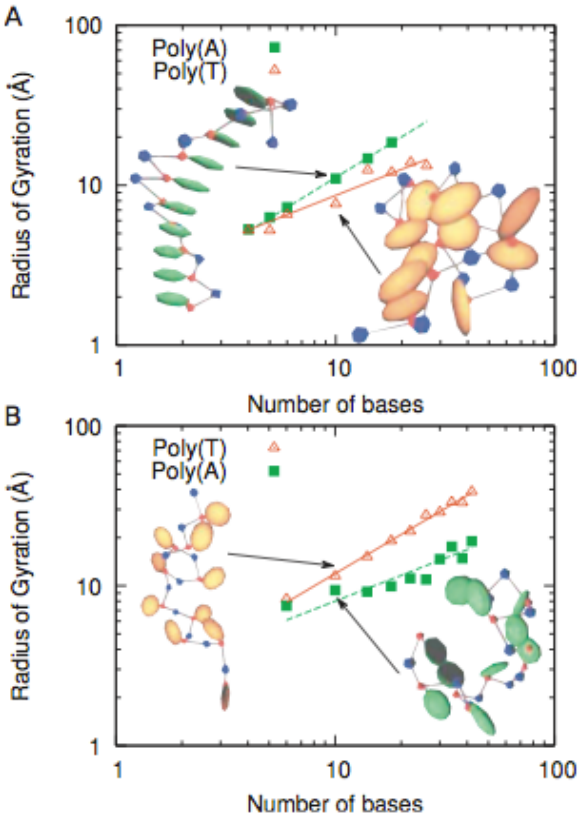
THE JOURNAL OF CHEMICAL PHYSICS **132**, 035105 (2010)

# A systematically coarse-grained model for DNA and its predictions for persistence length, stacking, twist, and chirality

Alex Morriss-Andrews, Joerg Rottler, and Steven S. Plotkin[a)]
*Department of Physics and Astronomy, University of British Columbia, 6224 Agricultural Road, Vancouver, British Columbia V6T1Z1, Canada*



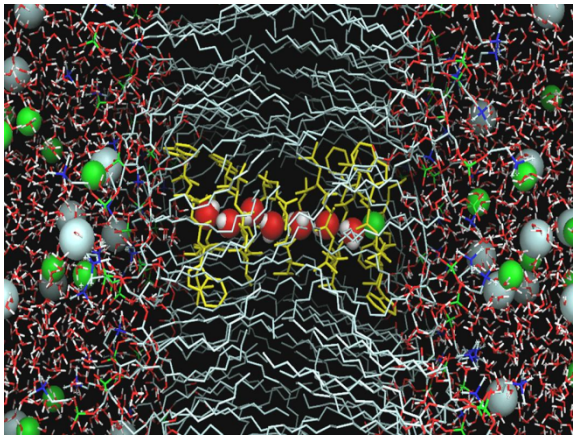



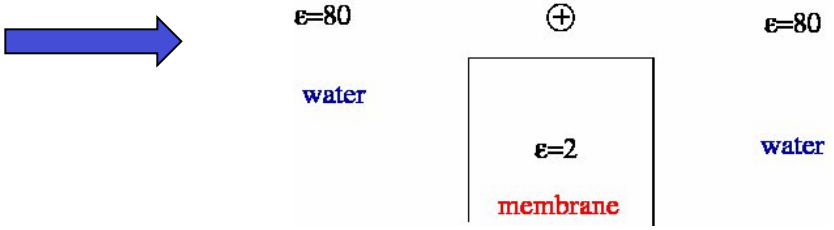



# Computational biophysics in Joerg Rottler's group

- New algorithms for electrostatic and dielectric effects in biomolecular systems

Translocation barrier of ion channels controlled by dielectric contrast

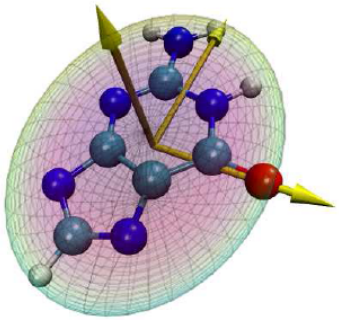





Gramicidin A atomistic MD

Coarse grained picture

- Coarse grained modeling of DNA (with Prof. S. Plotkin)



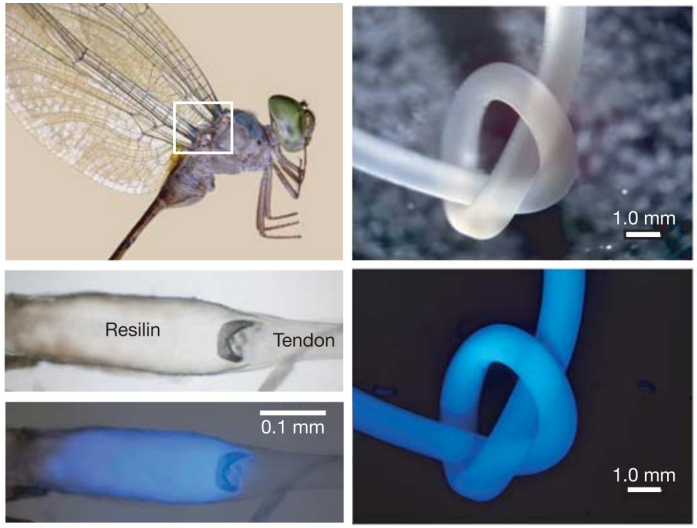
Construct simplified model of DNA by representing bases (ACTG) as ellipsoidal objects
Can reach longer timescales to study eg. translocation through nanopores, DNA looping, etc.

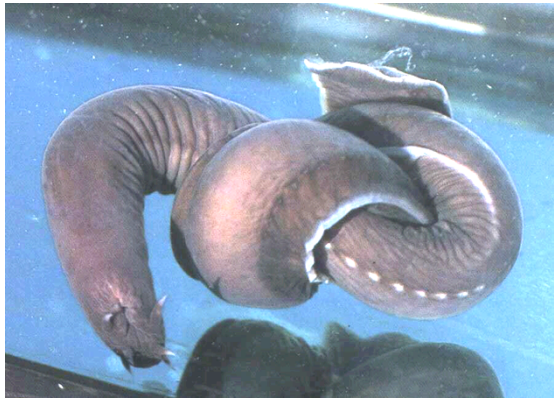
# Carl Michal – Solid-State NMR of biological materials

## Structure-properties-function relationships

Spider silk

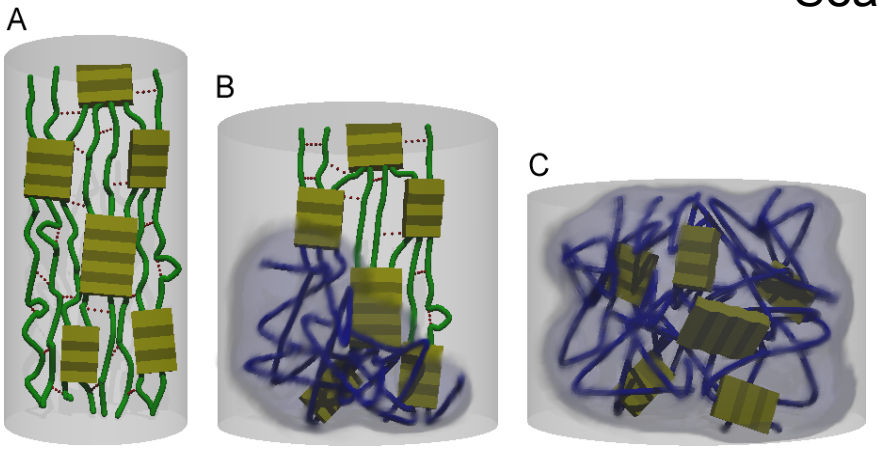
Resilin

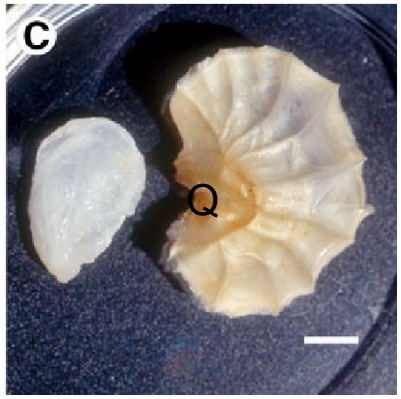


Hagfish slime threads

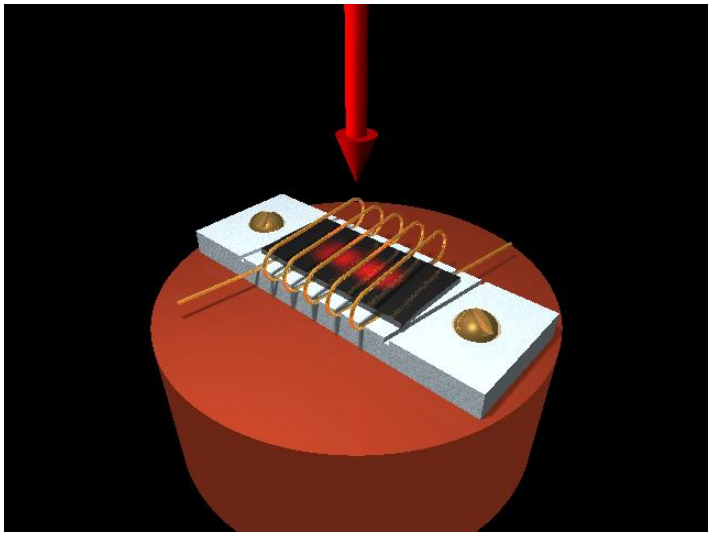
Sea-snail egg capsule



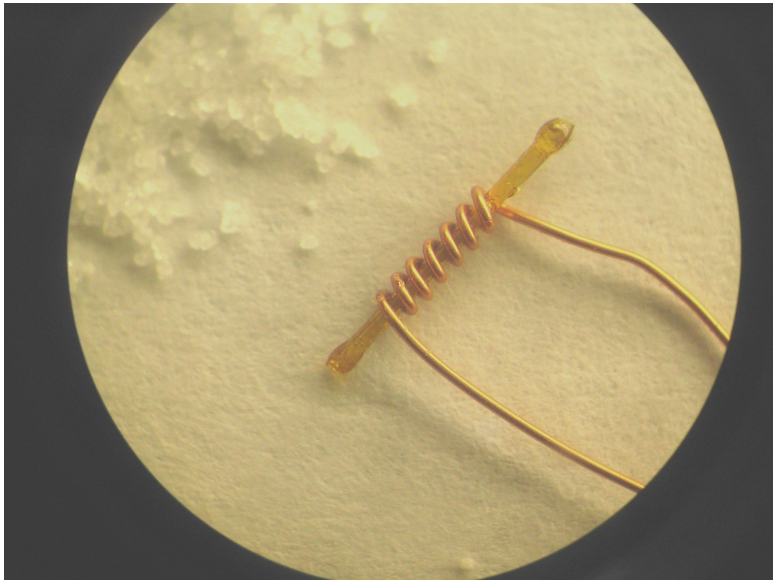



**Carl Michal**

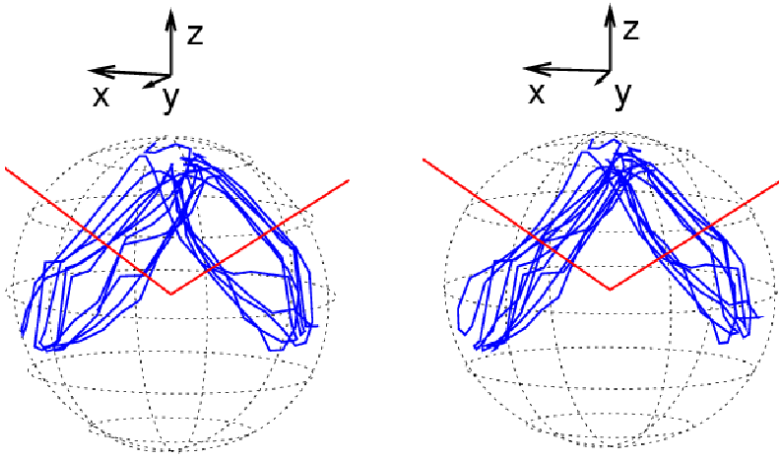
Novel NMR Techniques

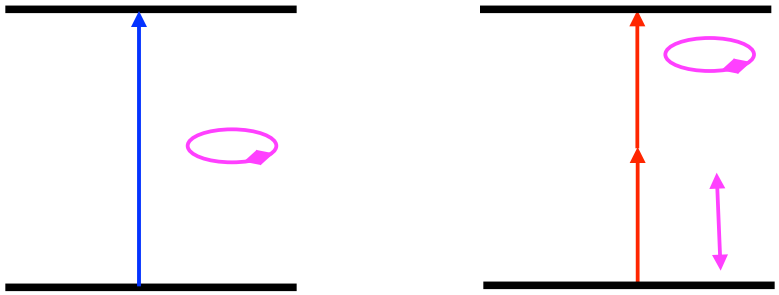


Optically Pumped NMR in semiconductors



Microcoils

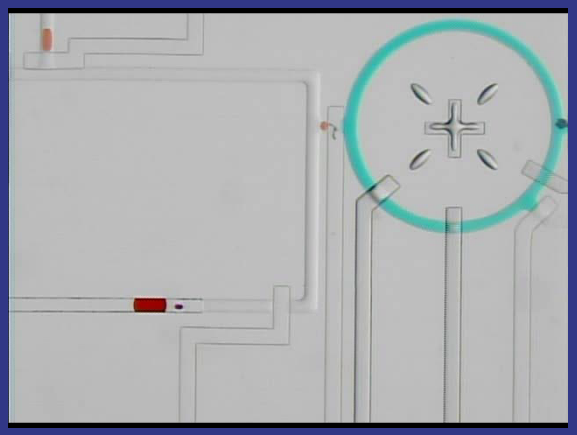


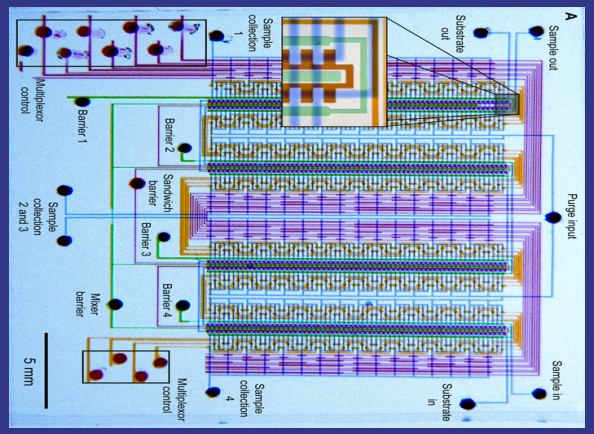



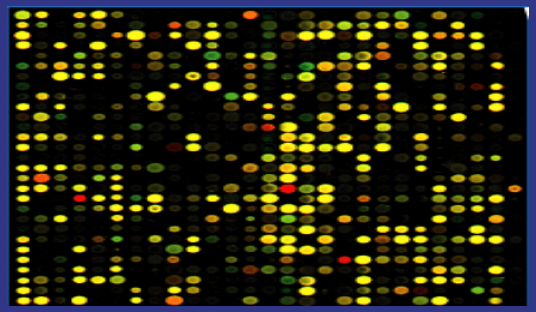
Two-photon NMR

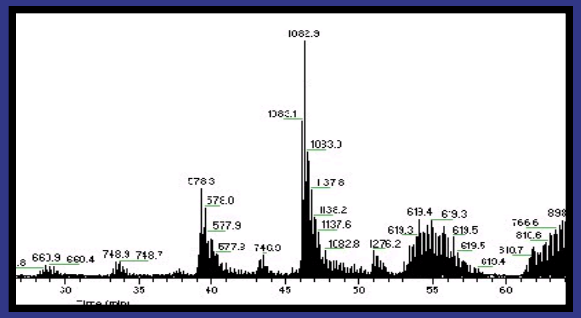
# Hansen Lab

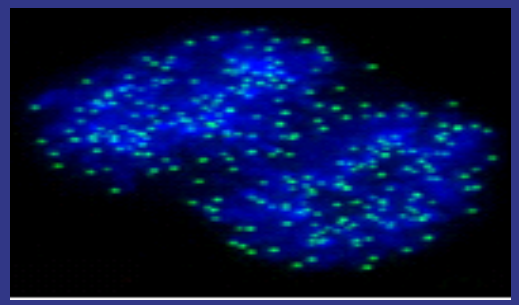
## Development and Application of Microfluidics Technology for High-Throughput Biology









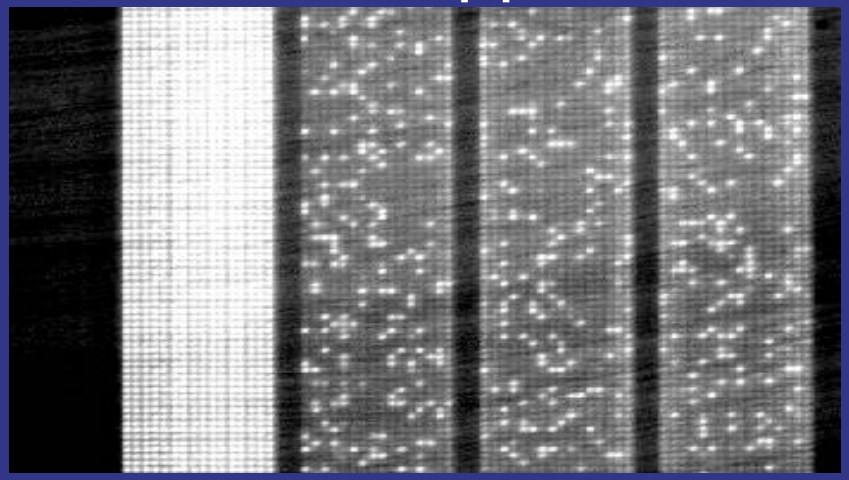
Genomics

Proteomics

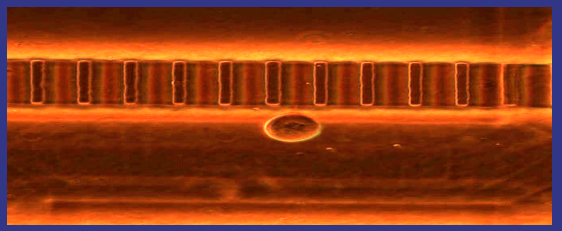
Cellomics

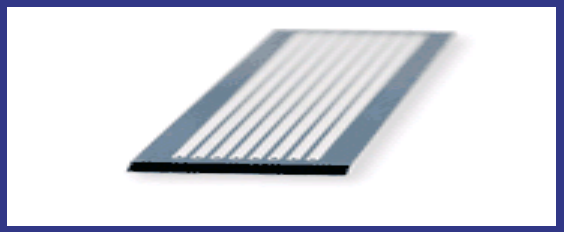
**Design, Fabrication, Testing, Discovery**

# Interdisciplinarity
# Broad Applications to Basic and Applied Biomedical Science

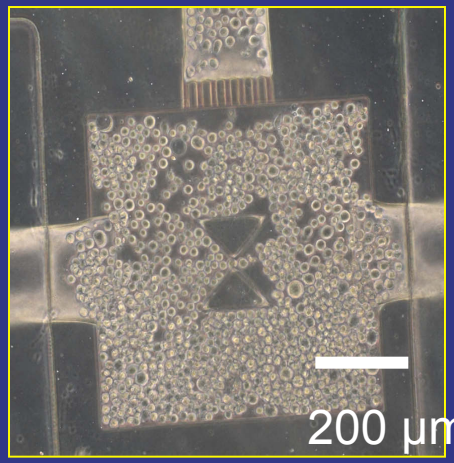


Counting Single Molecules

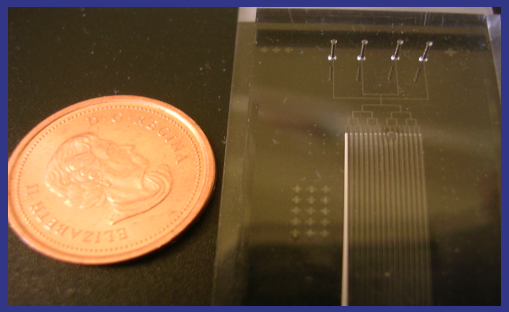


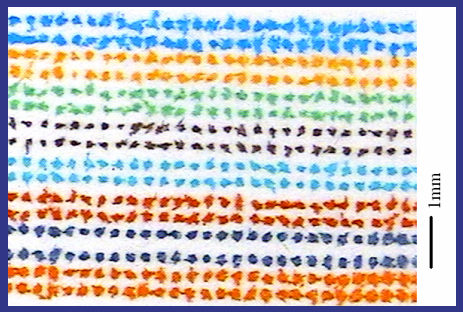


Single Cell Genomics




Miniaturized Stem Cell Culture

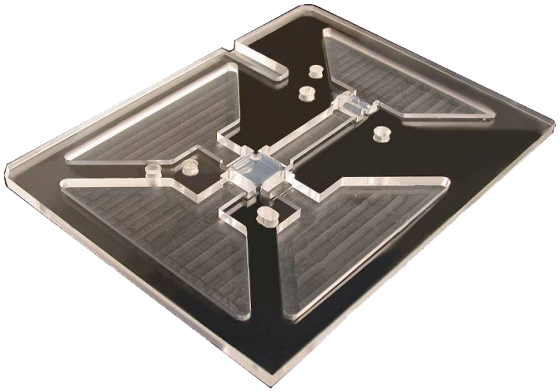


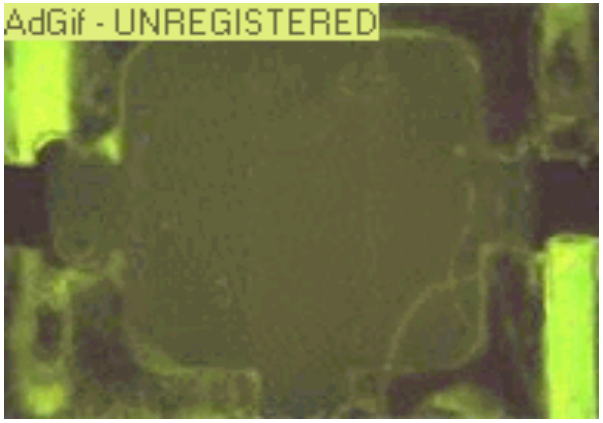


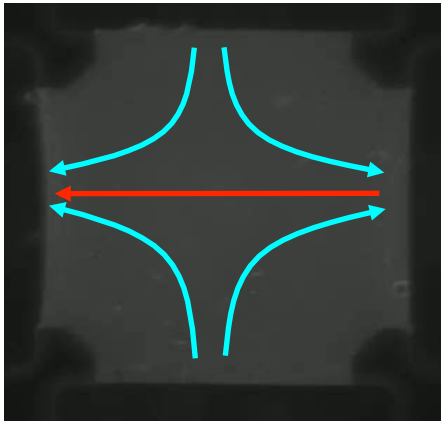

High-Throughput Proteomics

# Forensic DNA analysis

Boreal Genomics



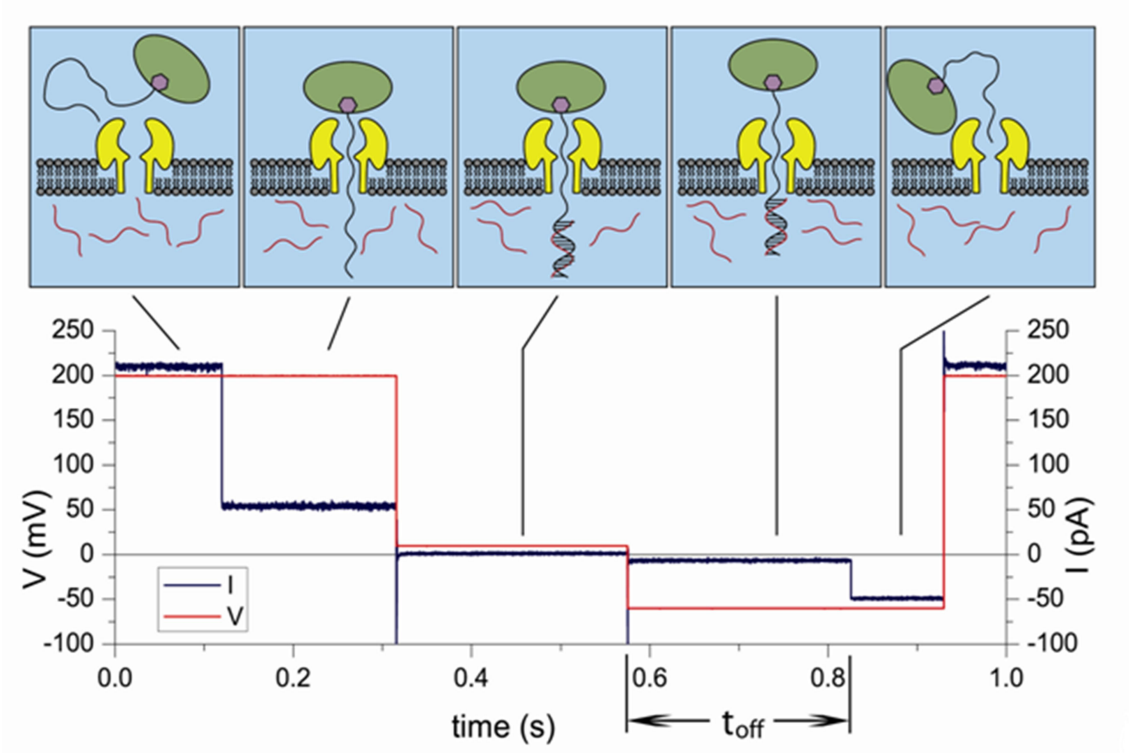


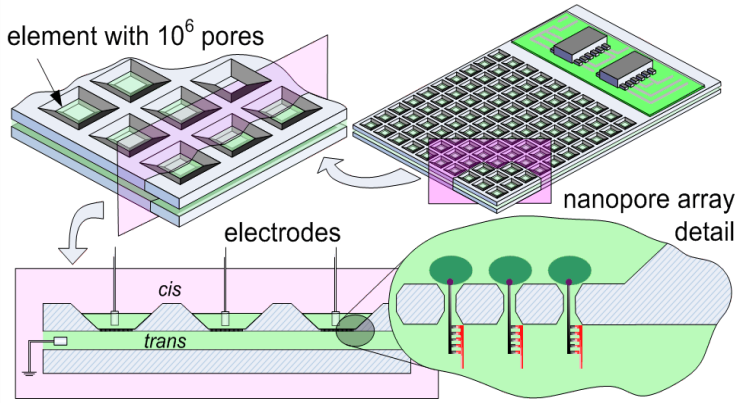



**We invented a way to concentrate and detect as few as *10 molecules of DNA* in a glass of water!**

**We started Boreal Genomics to commercialize this in: life science research, forensics, cancer detection**

# Single molecule nanopore analysis




**We assemble a single molecule sensor from DNA and proteins.**

**Using this sensor, we can analyse single DNA molecules and are working on analysis of prion molecules from Mad Cow disease.**