RNAnopore
Unzipping DNA with a nanopore

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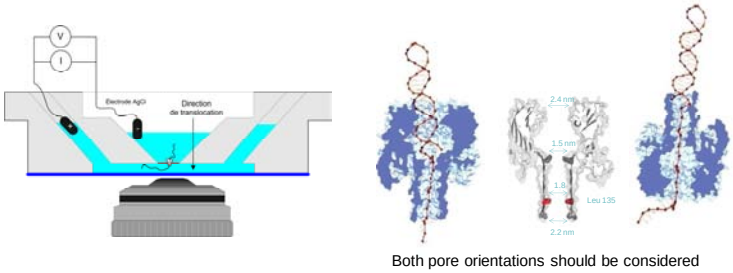
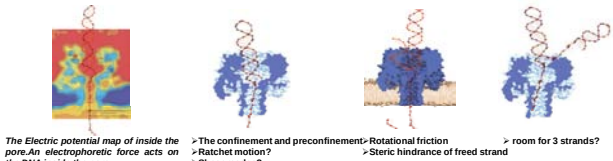
Rationale: We want to explore the possibility to study and address the folded states of nucleic acids by threading them through a pore with a diameter ranging between the diameter of a single DNA strand (1.5nm) and double DNA strand (2.2nm). The nucleic acids are electrophoretically driven one at a time through the pore resulting in transient ionic current blocades. In that respect the pore serves both as a nanosensor and as a force transducer. We study the shape and distribution of theses blocade events to infer the unzipping process.

The set up, the α-hemolysin pore



Both pore orientations should be considered

The geometrical constrains



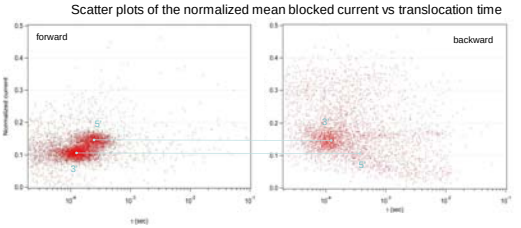
The Electric potential map of inside the pore.An electrophoretic force acts on the DNA inside the pore

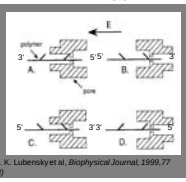
- The confinement and preconfinement
- Ratchet motion?
- Shear modes?
- Rotational friction
- Steric hindrance of freed strand
- room for 3 strands?

ssDNA translocation

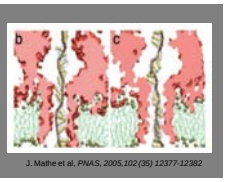
- 3' and 5' first orientations can be discriminated
- The electrophoretic force is the same in both orientation
- The vestibule acts as filter for aborted translocation

Scatter plots of the normalized mean blocked current vs translocation time





Christmas tree model



D. K. Lubensky et al, *Biophysical Journal, 1999,77 (4)*

J. Mathe et al, *PNAS, 2005,102 (35) 12377-12382*

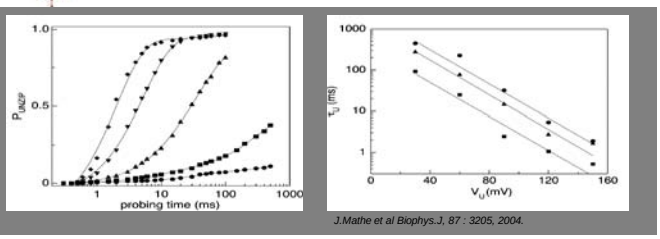
dsDNA translocation

- **Short DNA hairpins** open in a single activated step
- **Long DNA hairpins** open in multiple sequence dependent activated steps

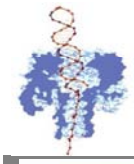
$$\tau_u = \tau_0 . \exp\left(\frac{E_b - Q_{eff} . V}{k_b T}\right)$$

$$\tau_0 . \exp\left(\frac{E_b}{k_b T}\right) \approx 200 - 1000\ ms$$

$$Q_{eff} \approx 0.1 - 0.2e / nucleotide$$



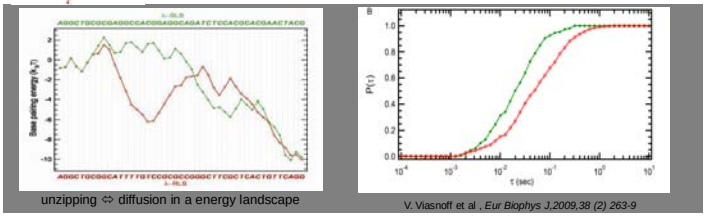
J.Mathe et al Biophys.J, 87 : 3205, 2004.



$$E_j^{duplex} = \sum_1^j \Delta H_i - T\Delta S_i$$

$$E_j = E_j^{duplex} - W . j$$

$$\nu_{mn} = \nu_0 \exp(-\frac{E_m - E_n}{2 k_b T})$$

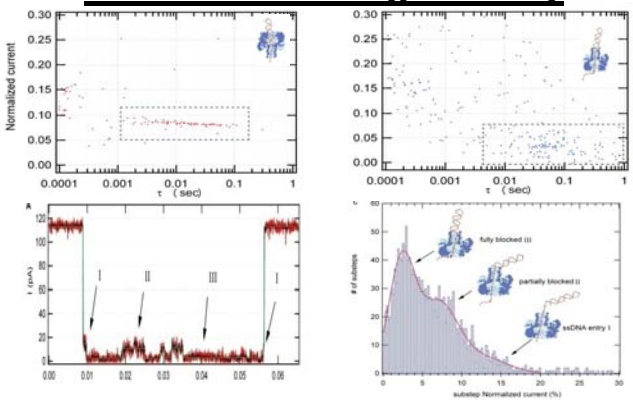


unzipping ⇔ diffusion in a energy landscape

V. Viasnoff et al , *Eur Biophys J,2009,38 (2) 263-9*

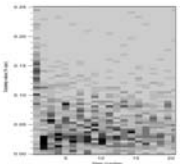
2 sequences with the same globale stability translocate with different speed

Influence of the geometry

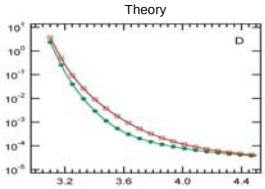


Typical translocation trace with substeps

2D histogram of substep values

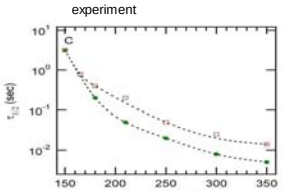


Theory



Average translocation time vs transmembrane voltage

experiment



V. Viasnoff et al , *Eur Biophys J,2009,38 (2) 263-9*

U. Bockelmann et al, *Biophys J, 2008,94 (7) 2716-24*

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