

Detecting Polymer Persistence Length

Introduction: Liz Conley

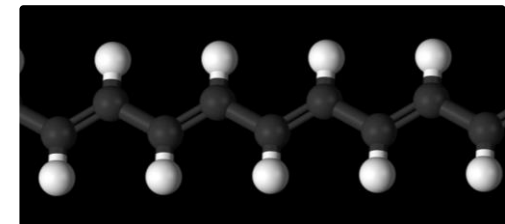
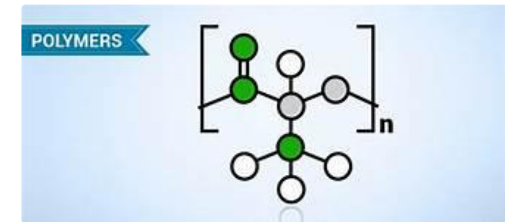
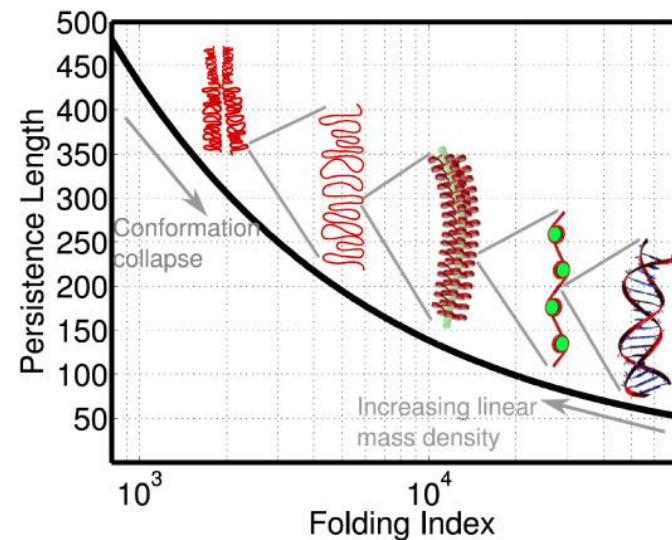
Undergraduate of Electrical
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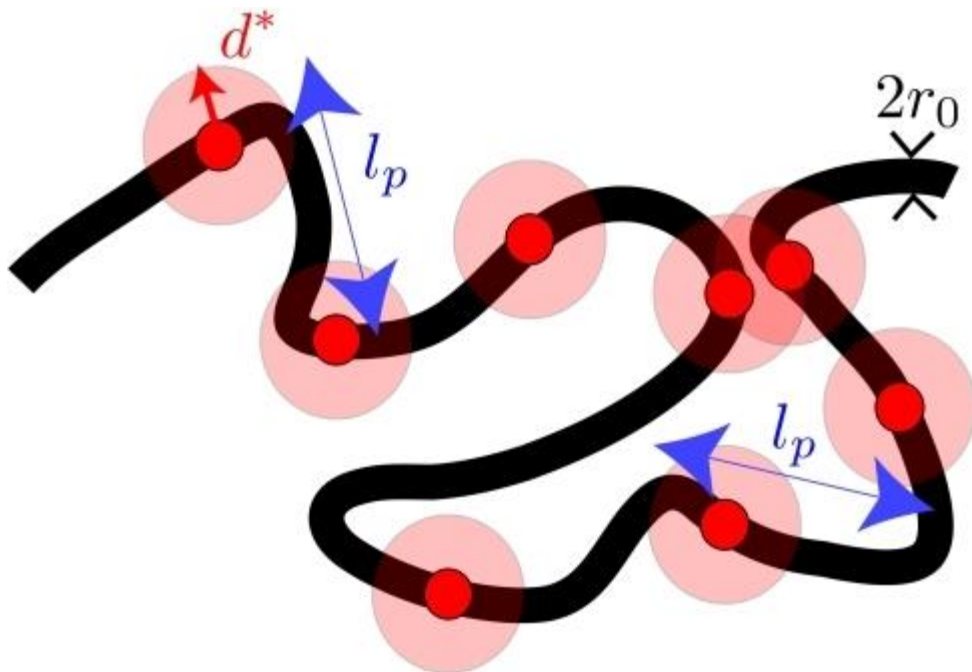
Polymer Physics and Persistence Length

- Polymer Physics
- Polymer Persistence Length and its significance



Models for determining polymer persistence length

The **Worm-Like Chain (WLC)** model



The **Freely-Jointed Chain Model**

- $\{\mathbf{R}_n\}$ = Position vector
- $\{\mathbf{r}_n\}$ = bond vector
- l = length of a link
- Mean square end-to-end vector

$$\langle R^2 \rangle = \langle \mathbf{r}_n \cdot \mathbf{r}_m \rangle = \sum_{i=1}^N \sum_{j=1}^N \langle \mathbf{r}_i \cdot \mathbf{r}_j \rangle \quad (1)$$

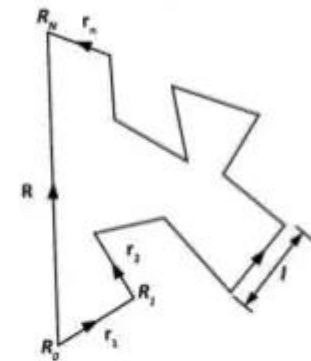


Fig.4. Freely jointed polymer.

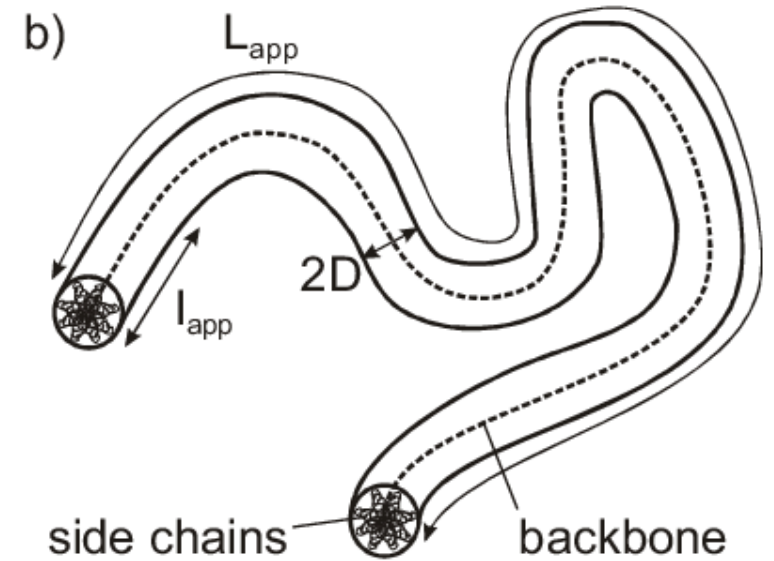
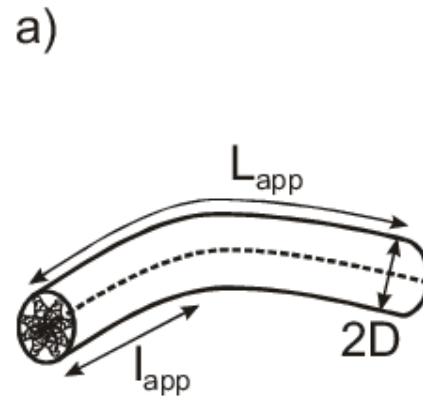
Purpose



Current methods lack precision and are time consuming

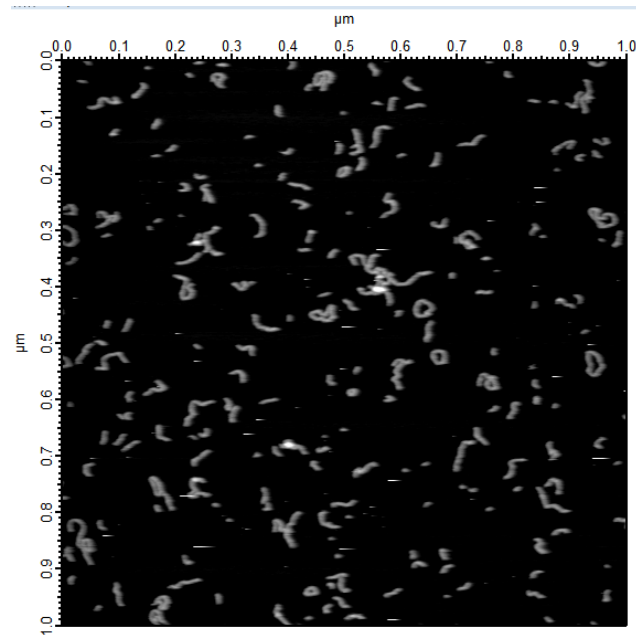


An automated backbone trace would create more accurate calculations in significantly less time

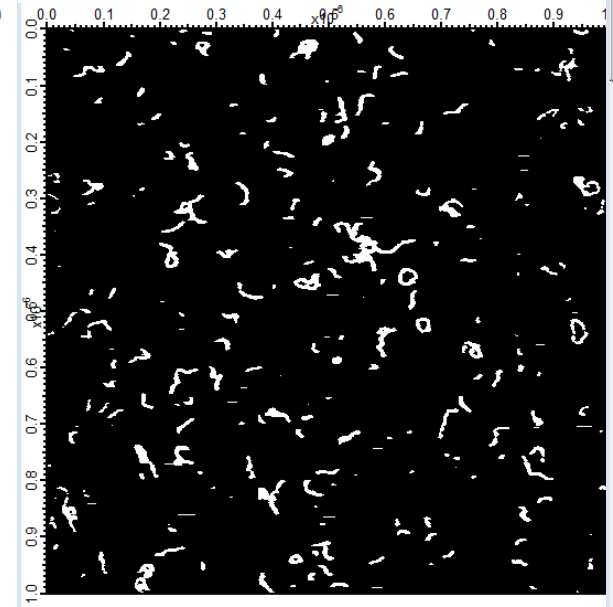


Methods

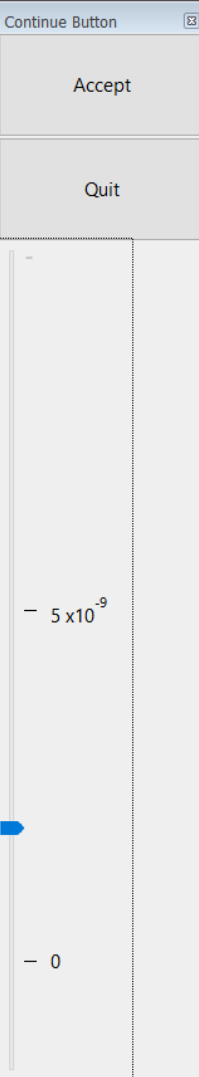
- ▶ The user selects an image of polymers
- ▶ A “heightmask” is then created and expanded
- ▶ Result of heightmask is fed into thinning algorithm



Raw image of CL



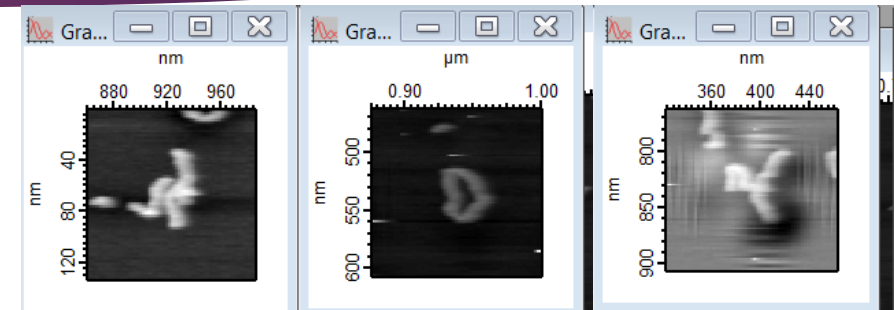
Same image
masked at a height
of 1.89nm



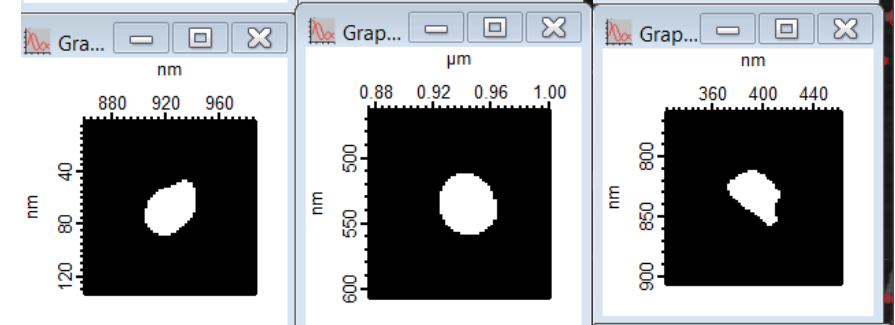
Methods

- ▶ The image is then separated into individual polymers for further analysis
- ▶ Threshold chosen for mask is used for a basis of surface thinning
- ▶ Lines are created along central position, or “backbone” of the polymer

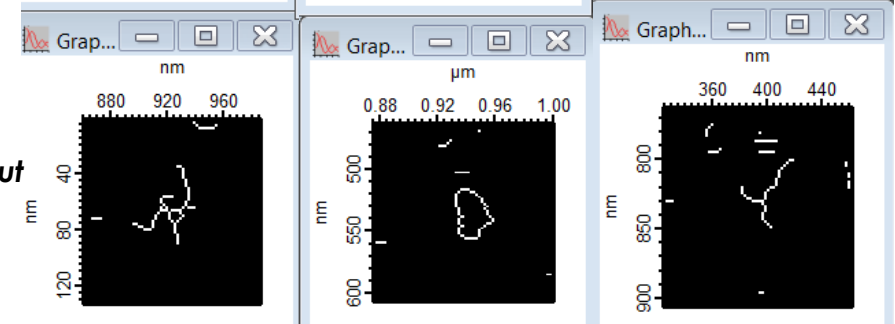
**Raw
particle**



**Particle with
applied
heightmask**

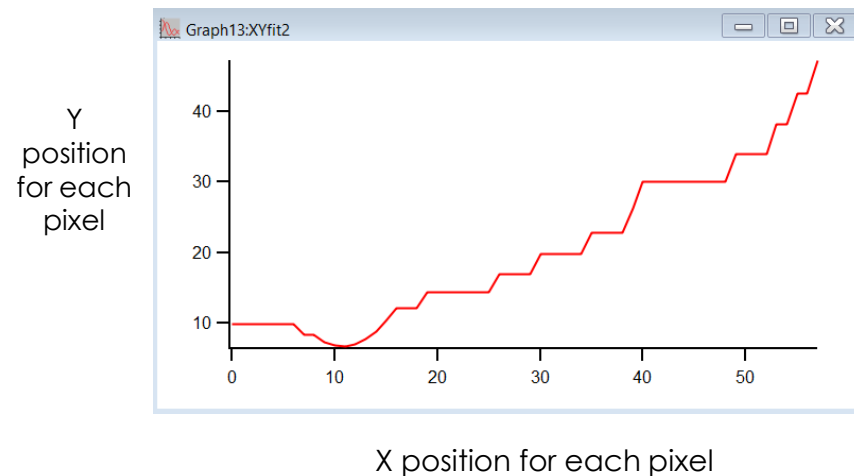
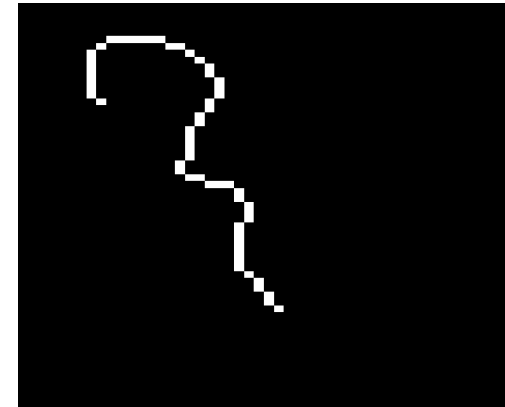


**Particle
backbone output
of thinning
algorithm**



Methods

- ▶ Noise is cleaned up and coordinates from each polymer
- ▶ Coordinates are transformed from pixel units to nanometers
- ▶ Measurements taken from each polymer contribute to statistical result of the persistence length



Testing

- ▶ Simulation program was developed using a monte Carlo based method to generate a user-defined number of polymer traces
- ▶ Polymer traces are placed randomly throughout a binary image
- ▶ Swelling function is applied to each 1 valued pixel
- ▶ creates a simulated image with an exact known persistence length

Data and Results: unfinished

Why?

- ▶ The simulation program is successfully generating polymers but the swelling function is a work in progress
- ▶ The persistence length algorithm is still buggy, takes while to run, and produces an inconsistent result

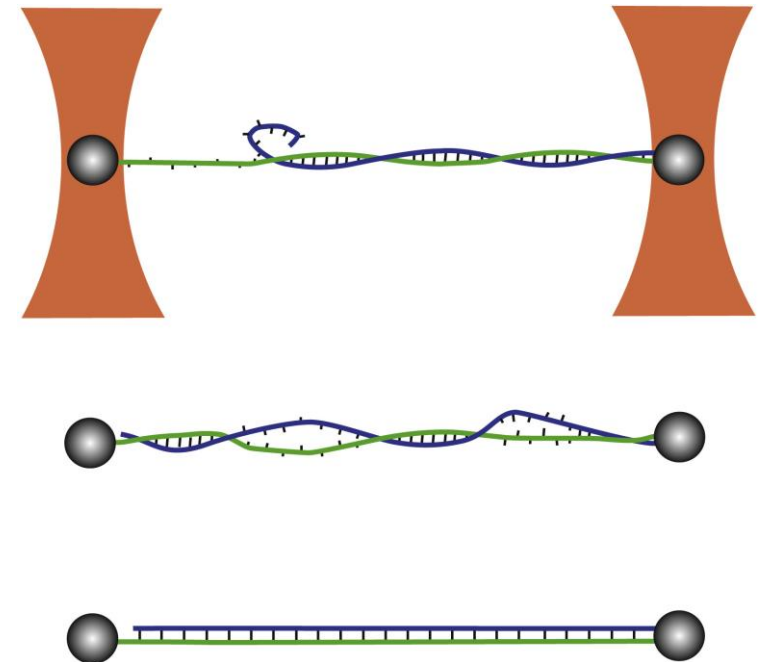
Limitations

- ▶ Only works for planar molecules spread evenly across the background surface
- ▶ Only one image can be analyzed at a time

Implications/Significance

The persistence length is informative to how individual polymers behave, providing a greater understanding for biological functions that occur on a larger scale.

For Example: The stability of double stranded DNA is owed to its high persistence length as it is much more rigid than single stranded DNA



Future Steps

- ▶ Add PL algorithm to “Hessian Blobs” to make a master program used in our lab
- ▶ Complete simulation software for multiple particle 3D
- ▶ Incorporate particles with knots
- ▶ Refine calculations for donut shaped polymers

Thank you!! 😊

- ▶ Lucas
- ▶ Gavin
- ▶ Katie