Binding-rebinding dynamics of proteins interacting nonspecifically with a long DNA molecule

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Many processes in cells are linked to the association and dissociation of proteins to and from DNA. The kinetics of binding and unbinding of proteins directly controls chromosome structure and function. The dynamics of the release of a protein from DNA (a macroscopic dissociation) will, in most cases, involve a number of rapid unbinding and rebinding events (microscopic dissociations) before the protein is able to escape from the region of the DNA it was bound to. This sequence of rebinding events is in turn dependent on the conformation of the DNA.

We have studied the relationship between macroscopic and microscopic dissociation of ligands (e.g. protein) from a long polymer (e.g. DNA) and have found that the total time that a ligand is bound depends on the length and conformation of the polymer.

Recent experiments indicate that the kinetics of release of proteins from a DNA can be much slower than one might expect from apparent binding affinities. One contributor to this effect may be the fact that microscopic dissociation from a particular binding site is quite likely to be followed by rebinding to a nearby binding site along the same DNA molecule, leading to an increase in the apparent “off time” from the DNA.

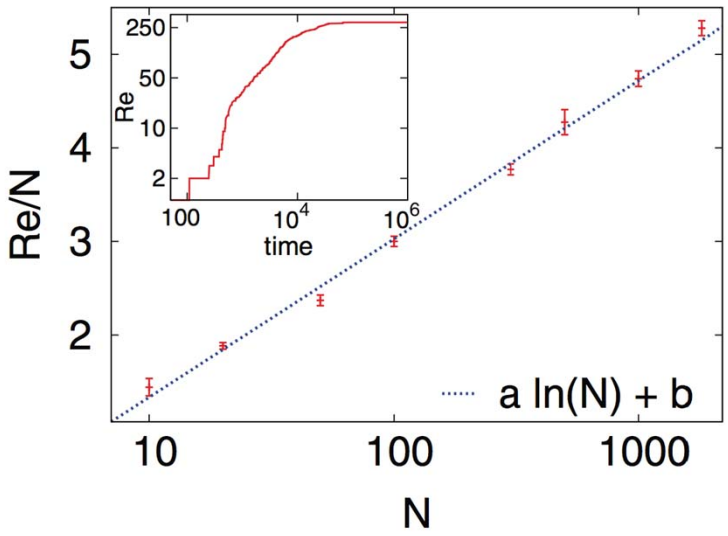

Figure: The average number of revisits per ligand ($Re/N = N_{revisits}$) is proportional to the logarithm of the length of the chain N.

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