Scaffold Assisted Chromosome Condensation: Molecular Dynamics Simulations

Dong-Gil Shin
MIT PRIMES
May 21, 2011
Mitosis and Chromosome Condensation

Interphase

Prophase

Metaphase

Anaphase

Telophase

Undergoes some 10,000 – 20,000 fold compaction and separates into sister chromatids
Separating chemically identical chains is a difficult feat.
Axial Scaffolds

Consists mainly of proteins Topoisomerase IIα and Condensin

*Can two identical scaffolds separate two identical sister chromatids?*

Molecular Dynamics Simulation

Two linear scaffolds in parallel

Short-range attractive potential
Chain length $N = 1000$

Freely jointed chain

Topoisomerase II introduced via semi-penetrable volume interaction

Topoisomerase passes one strand of DNA through another strand
Parameters Involved

- Strength of attractive potential energy
- Length of scaffold
- Distance between scaffolds
If attractive force is too strong
If attractive force is too strong
If attractive force is too strong
If attractive force is too strong
If attractive force is too strong
If too weak
If too weak
If too weak
If too weak
If too weak
If too weak
If too weak
If too weak
If scaffolds are too long
If scaffolds are too long
If scaffolds are too long
If scaffolds are too long
If scaffolds are too long
If scaffolds are too long
If scaffolds are too long
If scaffolds are too long
If the distance between the scaffolds is too small
If the distance between the scaffolds is too small
If the distance between the scaffolds is too small
If the distance between the scaffolds is too small
If the distance between the scaffolds is too small
If the distance between the scaffolds is too small
If the distance between the scaffolds is too small
If the distance between the scaffolds is too small
If the distance between the scaffolds is too small
If the distance between the scaffolds is too small
However, when the parameters fall within certain ideal ranges
However, when the parameters fall within certain ideal ranges
However, when the parameters fall within certain ideal ranges
However, when the parameters fall within certain ideal ranges
However, when the parameters fall within certain ideal ranges
However, when the parameters fall within certain ideal ranges
However, when the parameters fall within certain ideal ranges
However, when the parameters fall within certain ideal ranges
However, when the parameters fall within certain ideal ranges
However, when the parameters fall within certain ideal ranges

Quick and reliable separation occurs
Another Example
Another Example
Another Example
Another Example
Another Example
Another Example
Another Example
Another Example
Successful separation achieved under certain regimes suggests that scaffold assisted condensation may be a feasible mechanism.
Future directions

Gather quantifiable data concerning parameters involved and try to characterize ideal parameters numerically

Try more chain lengths and different starting chain positions

Look for other parameters that may be involved

Simulate a model more resembling the X-shape of the chromosome
Great Thanks to:

PRIMES
Prof. Leonid Mirny
Geoffrey Fudenberg and
Maxim Imakaev