

An Indian-Australian research partnership

Project Title:	<input type="text" value="Computing the dynamics of chromatin folding"/>	
Project Number	<input type="text" value="IMURA0631"/>	
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Monash Department:	<input type="text" value="Chemical Engineering"/>	
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IITB Co-supervisor(s) (Name, Email Id, Phone)	<input type="text"/>	
IITB Department:	<input type="text" value="Biosciences and Bioengineering Department"/>	

Research Academy Themes:

Highlight which of the Academy's Theme(s) this project will address?

(Feel free to nominate more than one. For more information, see www.iitbmonash.org)

1. **Advanced computational engineering, simulation and manufacture**
2. Infrastructure Engineering
3. Clean Energy
4. Water
5. Nanotechnology
6. Biotechnology and Stem Cell Research

The research problem

The fate of a cell is decided by the "state" of its chromatin. Chromatin is nothing but the packaged form of DNA---a long string (polymer) that carries our genetic information. Understanding and defining different states of a chromatin is a huge task, and some major factors that decide chromatin state are the nucleosome-positioning (positioning of some proteins on DNA) and 3D architecture of the genome (DNA). Existing experiments provide us only frozen snapshots of nucleosome positioning and 3D genome architecture. However to understand the fate of a cell (gene expression/regulation) one needs to combine these different sets of information available and make a dynamic model that can predict the active steady-states of chromatin, under a given condition. In this project we propose to make a multi-scale model that can predict the dynamics of chromatin packaging.

Project aims

The aim of this project is to make a polymer model that can study the dynamics of chromatin packaging on the scale of many genes. We would use Brownian dynamics-based methods to study the dynamics of the folding of chromatin. Our simulations will help us to understand how local structures/elements such as

nucleosome density and positioning dictate the dynamics of folding. We also aim to learn how various fundamental interactions (curvature created by proteins on the DNA, nucleosome-nucleosome interaction etc) determine the rate of folding and the nature of local folded structures. These are important in the context of transcription-factor accessibility and gene regulation.

Expected outcomes

The outcomes of the project will include:

- (i) The development of a validated software tool that can directly compute the dynamics of chromatin folding at the scale of many genes
- (ii) Understanding of different chromatin states given a particular arrangement of proteins on the DNA.

How will the project address the Goals of the above Themes?

Using theory and simulation we ultimately aim at understanding the dynamics of chromatin packaging on the scale of many genes, which is a problem of fundamental importance in the field of biophysics. Only a combination of computer simulation and theoretical techniques can shed light onto such complex dynamical process. This project will firstly enhance our ability to understand mechanisms in biological systems such as biological cells. The outcome of this project will contribute to enabling aspects of the Strategic Research Priority “Living in a changing environment” and understanding the fundamental molecular aspects of Biodiversity—all of which is essential for harnessing biomolecular processes whether in health care or biotechnology.

Capabilities and Degrees Required

The following capabilities are essential:

1. Excellent training in mathematics and numerical methods (biology knowledge is not mandatory)
2. Proven experience with computer programming in high level languages
3. Ability to write and communicate fluently
4. Strong background in Engineering/Physics (Either M Sc in Physics or B Tech/BE in Mechanical/Chemical/Electrical Engg)
5. While the topic has a biological context, students **without a background** in physics or engineering will not be considered. BTech Biotechnology students need not apply.

Please provide a few key words relating to this project to make it easier for the students to apply.

Polymer dynamics, Brownian dynamics simulations, DNA packaging