

Annexe: NUS Mechanobiology Institute – New Research Thrusts

The Mechanobiology Institute (MBI) at the National University Singapore (NUS) focuses on understanding the fundamental aspects of how cells and tissues sense and respond to mechanical forces. Through three main research thrusts, MBI aims to translate fundamental research findings into practical applications in the fields of biomedicine and bioengineering.

Thrust 1: Cellular Mechanobiology

Understanding how cells convert mechanical stimuli into biochemical signals is crucial for developing targeted therapies for diseases. The focus of this thrust is on how cells interact with their surrounding matrix and how these interactions change across disease states.

Projects include:

- Nanoscale organisation of cell-matrix interactions
- Integration of mechanotransduction with cellular processes
- Force transmission at cellular junctions
- Impact of mechanical forces on ion channels and osmotic adaptation

Project Highlight:

Investigating how cells interact with surrounding matrix at the nanoscale

Small nanoscale alterations in properties of the extracellular matrix surrounding a cell can have profound impacts on mechanosignalling and subsequent cell behaviour. Researchers are combining advanced imaging and nanoengineering approaches to observe and modulate the biophysical properties of these surroundings. This detailed knowledge of how cells communicate with their surroundings in healthy, aged, or disease situations will inform development of new nanoscale biomaterials that can be used to regulate these interactions for therapeutic benefit.

Thrust 2: Tissue Mechanobiology

This thrust explores the mechanical underpinnings of cell differentiation and tissue organisation. Key investigations revolve around how cells collectively maintain tissue health and respond to injuries — with a particular focus on age-associated diseases relevant to Singapore's ageing population.

Projects include:

- Mechanics involved in the development and maturation of ovarian follicles
- Cell dynamics involved in liver regeneration and how fat cells disrupt the interactions between liver and muscle cells
- Dermal (skin) tissue resilience and extracellular matrix maintenance
- Control of angiogenesis (formation of new blood vessels) through actin and microtubule remodelling
- Dynamics of sperm maturation
- Cellular clearance mechanisms for maintenance of healthy tissues

Project Highlight:

Investigating how tissue mechanics lead to the maturation of the ovarian follicle

The development of eggs within the ovarian follicle is a mechanically sensitive process. By combining 3D culture systems, light-sheet microscopy and force sensors, researchers can map the force interactions and study the cellular response to mechanical changes in the

ovarian environment. This will provide insights into enhancing fertility treatments and disease prevention related to ovarian health.

Thrust 3: Mechanomedicine

MBI aims to advance mechanomedicine by applying mechanobiology science in medical diagnosis and treatment. To validate research findings and facilitate their practical application, MBI will collaborate with clinicians and industrial partners such as those from the National University Healthcare System.

Projects include:

- Development of diagnostic immunoassay platforms
- Mechanical conditioning of stem cells
- Drug screening to target mechanotransduction (i.e. the process by which cells convert mechanical signals or forces into biochemical responses)
- Mammalian cell selection via magnetic forces
- Microfluidic technologies for cell isolation

Project Highlight:

Advancing the rapid detection and quantification of biomarkers

Rapid and sensitive tools for detecting soluble biomarkers in blood are vital for disease diagnosis and monitoring. MBI researchers are developing easy-to-use diagnostic tools with high sensitivity and specificity that are scalable and have potential applications in diagnosing cancers and neurodegenerative diseases such as Alzheimer's disease.