Title of Project : Integrated nano-biomechanics

Takami Yamaguchi
(Tohoku University, Graduate School of Biomedical Engineering, Professor Emeritus)

Research Area : Biomedical engineering
Keyword : Biomechanics, computational biomechanics, experimental biomechanics, theoretical biomechanics, biomedical engineering

【Purpose and Background of the Research】

A biological system has a hierarchical structure, consisting of molecules, cells, tissues and organs. To understand pathophysiological phenomena, we must clarify interactions from molecular to organ levels. In this project, we will establish "Integrated nano-biomechanics" for analyzing multi-scale interactions in pathophysiological phenomena. We integrate computational, theoretical, and experimental biomechanics at the molecular, cellular, tissue, and organ levels. We will clarify biomechanics of diseases, including an infectious disease, malaria, cancer metastasis, primary ciliary dyskinesia etc., and will develop new methods for the prediction, diagnosis and treatment of such diseases.

【Research Methods】

We establish integrated nano-biomechanics by a bottom-up approach from the molecular level to the organ level (Fig. 1).

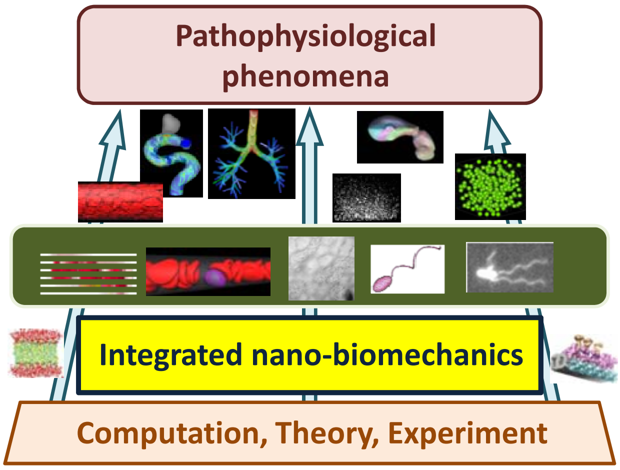

Fig. 1. Integrated nano-biomechanics

At the molecular level, we develop a numerical model of ligand-receptor bindings, based on binding kinetics measured by atomic force microscopy, for simulating cytoadhesion of malaria-infected red blood cells. The axonemal structure of respiratory cilia is also clarified using cryo-electron tomography to numerically model ciliary motion.

These models at the molecular level are extended to cellular models, such as a red blood cell model, a platelet model, a cancer cell model, and a ciliated cell model. We then simulate cytoadhesion of malaria infected red blood cells, thrombogenesis, cancer metastasis, primary ciliary dyskinesia, and swallowing disorders at the tissue and organ levels.

【Expected Research Achievements and Scientific Significance】

Integrated nano-biomechanics will give novel understandings of diseases from the mechanical perspective. We will be able to predict the progress of diseases on computers to provide new diagnosis and treatment methods.

【Publications Relevant to the Project】

- Ueno H, Ishikawa T, Bui KH, Gonda K, Ishikawa T, Yamaguchi T, "Mouse respiratory cilia with the asymmetric axonemal structure on sparsely distributed ciliary cells can generate overall directional flow", Nanomedinine, 8, 1081-1087 (2012).
- Imai Y, Kobayashi I, Ishida S, Ishikawa T, Buist M, Yamaguchi T, "Antral recirculation in the stomach during gastric mixing", Am J Physiol Gastrointest Liver Physiol, 304, G536-G542 (2013).

【Term of Project】 FY2013-2017

【Budget Allocation】 448,900 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.pfsl.mech.tohoku.ac.jp/nanobiomech/index.html
takami@nanobme.org