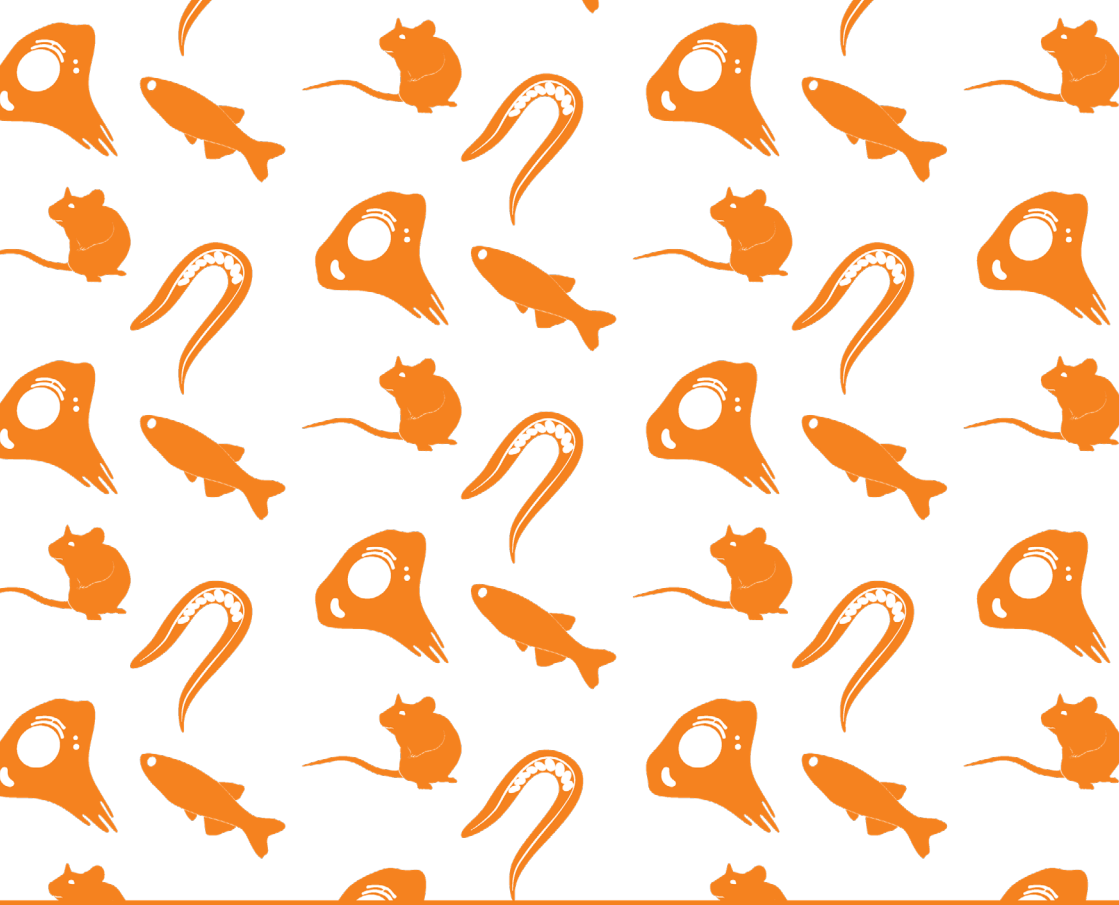


Bootcamp 2019:

An Integrative Approach to Understand Cell Function

Event schedule for

1 August to 10 August

MB5104: AN INTEGRATIVE APPROACH TO UNDERSTAND CELL FUNCTION

Otherwise known as:

Bootcamp 2019

The Bootcamp aims to bring together new life sciences graduate students, regardless of their background. Each morning, there will be lectures based on topics relevant across biophysics, cell, and developmental biology. The afternoon sessions will focus on practical skills, in particular, the use of Matlab. Interweaved with both morning and afternoon sessions will be problem sets.

A key element of the Bootcamp is teamwork. To begin with, you will be assigned into groups of around four students. These groups have been chosen to mix students of different academic backgrounds, from materials engineering to geneticists. You will work in these groups to produce a report and talk on a "hot topic" in cell biology. To encourage teamwork, groups will be graded as one, based on performance of all members. During the afternoon practical sessions and problem solving teamwork is also strongly encouraged; learning is achieved through active participation, including teaching others.

Each group will write a report and present its key conclusions at the end of the Bootcamp. The topics focus on areas where there is often uncertainty or misunderstanding. It is important to be critical and to provide a balanced summary. All group members must contribute to the writing and presentation of the report.

In the space of such a short course, we cannot cover all relevant topics for the start of your graduate studies. Therefore, we focus on developing your critical skills and collaborative tools – both of which will serve you well in your graduate research. We describe the cell from a mechanistic perspective and also discuss different model systems and genomic techniques that allow different biological questions to be studied.

We complement this with microscopy and quantitative techniques that enable the cell to be probed in detail. Finally, we include a basic introduction to modelling of biological systems and common mistakes made in statistical analysis in biology. Alongside all of this, we will develop your computational techniques which will enable you to perform the quantitative analysis that is essential in modern biological research.

This course provides you with a strong breadth of knowledge before you begin your research rotations. You will also gain insight into techniques that are available in Singapore that may assist you in your studies. As you progress through your graduate studies, you will have the opportunity to add depth to this knowledge.

Timothy Saunders and Yusuke Toyama

Bootcamp 2019 Timetable

(for registered students leading to 4-MC)

MB5104: An Integrative Approach to Understand Cell Function

1st August to 10th August 2019

Venue:

TLS - T-Lab Seminar Rooms: 5A Engineering Drive 1, T-Lab Building, Level 5, S117411

CT - CREATE Theatrette, Level 2, 1 CREATE Way, CREATE Tower, S138602

CS- CREATE Seminar Room, Level 2, 1 CREATE Way, Create Tower, S138602

Directions to CREATE Tower and T-Lab Building can be found:
T-Lab Building: temasek-labs.nus.edu.sg/about/about_visitor.php
CREATE Tower: create.edu.sg/contact-us

DAY 1

Date	Time	Content	Lecturer	Venue
Thursday **1st Aug 2019**	3:45-4:15pm	Registration		Outside TLS
	4:15-4:45pm	Introduction to the bootcamp	Assoc. Prof. Toyama and Asst. Prof. Saunders	**TLS**
	4:45-5:00pm	Safety briefing	Ms. Tan Bee Leng	
	5:00-7:00pm	The cell as a machine	Prof. Sheetz	

DAY 2

Date	Time	Content	Lecturer	Venue
Friday **2nd Aug 2019**	9:00-10:00am	The cell cytoskeleton	Prof. Yu	**TLS**
	10:00-10:45am	Cell compartments	Prof. Jedd	
	10:45-11:15am	*Break*		
	11:15-12:00pm	Cellular shape and polarization	Asst. Prof. Motegi	**TLS**
	12:00-1:00pm	*Lunch*		
	1:00-4:00pm	Introduction to Matlab (I)	Asst. Prof. Saunders Dr. Makhija	**TLS**
	4:00-4:30pm	Group assignments	Assoc. Prof. Toyama Asst. Prof. Saunders	
	4:30-5:15pm	How to write well	Assoc. Prof. Monteiro	
	5:15-6:00pm	How to present well	Assoc. Prof. Monteiro	
	6:00pm~	Social event		

DAY 3

Date	Time	Content	Lecturer	Venue
Saturday 3rd Aug 2019	9:00-10:00am	How fluorescence works	Asst. Prof. Saunders	**CT**
	10:00-10:30am	History of GFP	Asst. Prof. Saunders	
	10:30-11:00am	*Break*		
	11:00-12:00pm	Introduction to microscopy	Prof. So	**CT**
	12:00-1:00pm	*Lunch*		
	1:00-6:00pm	Optics tutorial	Assoc. Prof. Kanchanawong Asst. Prof. Loh Asst. Prof. Saunders	**CS**

DAY 4

Date	Time	Content	Lecturer	Venue
Sunday 4th Aug 2019	9:00-12:00pm	Introduction to Matlab (II)	Asst. Prof. Saunders Dr. Makhija	**CS**

DAY 5

Date	Time	Content	Lecturer	Venue
Monday 5th Aug 2019	8:30-10:00am	Gene editing	Dr. Lieu	**TLS**
	10:00-10:30am	*Break*		
	10:30-11:30am	Genomes	Dr. Lieu	**TLS**
	11:30-12:30pm	Genomes worksheet	Dr. Lieu	
	12:30-1:30pm	*Lunch*		
	1:30-6:30pm	Sample preparation and wetlabs (Block S16, #02-04)	Dr. Lieu	**Blk S16**

DAY 6

Date	Time	Content	Lecturer	Venue
Tuesday **6th Aug 2019**	9:00-9:45am	Perturbing the cell	Assoc. Prof. Toyama	**TLS**
	9:45-10:30am	Super-resolution microscopy	Assoc. Prof. Kanchanawong	
	10:30-11:00am	*Break*		
	11:00-11:45am	Electron microscopy	Dr. Kostyuchenko	**TLS**
	11:45-12:30pm	Single molecule manipulation	Prof. Yan	
	12:30-1:30pm	*Lunch*		
	1:30-5:30pm	Microscopy	MBI (Asst. Prof. Saunders) CBIS (Assoc. Prof. Toyama) SMART (Dr. Makhija)	MBI, CBIS & SMART
	5:30-6:00pm	*Break*		
	6:00-8:00pm	Mechanopathology of diseases – from bench to bedside	Prof. Lim	**TLS**

DAY 7

Date	Time	Content	Lecturer	Venue
Wednesday **7th Aug 2019**	*Student orientations - no lectures/classes*			

Date	Time	Content	Lecturer	Venue
Thursday **8th Aug 2019**	9:00-9:30am	Introduction to bacteria	Dr. Mon Dr. Singh	**TLS**
	9:30-10:00am	Introduction to yeast	Assoc. Prof. Yeong	
	10:00-10:30am	Introduction to *Drosophila*	Assoc. Prof. Wang	
	10:30-11:00am	*Break*		
	11:00-11:30am	Introduction to fish	Assoc. Prof. Winkler	**TLS**
	11:30-12:00pm	Introduction to plants	Asst. Prof. Chae	
	12:00-1:00pm	*Lunch*		
	1:00-2:00pm	Statistical methods for biology	Asst. Prof. Carrasco	**TLS**
	2:00-3:00pm	Perils of the p-value	Asst. Prof. Saunders	
	3:00-5:00pm	Statistics in biology discussion with coding	Assoc. Prof. Toyama Asst. Prof. Saunders	
	5:00-5:30pm	*Break*		
	5:30-7:30pm	Evolution of complex traits	Assoc. Prof. Monteiro	**TLS**

DAY 9

Date	Time	Content	Lecturer	Venue
Friday **9th Aug 2019**	9:00-12:00pm	Image analysis with Matlab and image J	Asst. Prof. Saunders Dr. Makhija	**TLS**

DAY 10

Date	Time	Content	Lecturer	Venue
Saturday **10th Aug 2019**	9:00-10:30am	Presentation	Assoc. Prof. Toyama Asst. Prof. Saunders Dr. Makhija Dr. Lieu	**CT & CS**
	10:30-11:00am	*Break*		
	11:00-12:30pm	Presentation	Assoc. Prof. Toyama Asst. Prof. Saunders Dr. Makhija Dr. Lieu	**CT & CS**
	12:30-1:30pm	*Lunch*		
	1:30-6:00pm	Writing and image analysis workshop	Assoc. Prof. Toyama	**CS**
	End of bootcamp classes			

Date	Time	Content	Lecturer	Venue
Wednesday **14th Aug 2019**	6:00pm	Deadline for submission of report		

Bootcamp Report Topics 2019

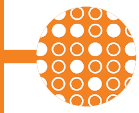
Each group should rank their top 5 choices (in order) for the topic they wish to investigate and submit these by lunch time on **Saturday, 3 August**. Each group will know its topic by the evening of the same day.

1. Model organisms for studying cell biology

Why it is still important to study yeast and other similar organisms? What advantages do they give compared to investigating human cell behaviour directly?

2. Suitability of model organisms for studying human diseases

Organisms such as *Drosophila* and mouse have been used to better understand a range of human diseases (e.g. cardiomyopathies, cancer). However, such work has had limited success in creating effective treatments for human diseases. Here, discuss the efficacy of model organisms in studying disease, looking at both advantages and disadvantages. Outline at least one study where a human disease has been successfully tackled using discoveries first found in a non-vertebrate model organism and one where a successful treatment in a mouse disease did not translate into an effective human treatment for the same disease.



3. Next generation sequencing has made genome sequencing fast and inexpensive.

If the cost of genome sequencing drops to $10 a piece, what biological question(s) would you ask?

4. Genome editing

Cheap and effective methods have made genome editing in humans a realistic possibility. Where should a line be drawn? What are the social and ethical considerations that need to be accounted for? What diseases would you prioritise for treatment? For each answer, focus on giving the scientific evidence.

5. Super-resolution microscopy for live imaging

Super-resolution microscopy (e.g. STED and STORM) have both revolutionized imaging in biology. However, they have distinct limitations, particularly when it comes to imaging live samples. Discuss how super-resolution can be used to image live samples, including cells in culture and living organisms (e.g. embryos). The report should clearly outline the causes of the limitations in super-resolution microscopy and discuss how these may be overcome.

6. Understanding epithelial tissues: *in vitro* vs *in vivo* approaches

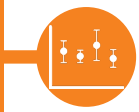
Epithelial tissue cultures have provided a powerful tool for understanding cell function and cell-cell interactions. However, such approaches take cells out of their physiological environment. Recent genetic and microscopy advances have enabled cellular processes and epithelial tissues to be imaged *in vivo*. The report should compare *in vitro* and *in vivo* approaches and discuss, in detail, their relative (dis)advantages.

7. Protein manipulation: genomic vs external perturbations

A key technique for understanding protein function is to inhibit or over-activate its function. This can be achieved genetically, by mutating the DNA that encodes the protein. External perturbations, such as drug treatments or temperature shocks, can also alter protein function. The report should compare different techniques for altering protein function, and in particular, discuss their efficacy in deciphering protein function. *in vivo* and *in vitro* systems should be discussed.

8. Quantifying fluorescence and problems faced

Fluorescence imaging is increasingly used in cell and developmental biology. However, quantifying fluorescence imaging data is non-trivial. Discuss how to quantify different types of fluorescence data, and describe the different strategies for correcting for background signals. Problems with fluorescence imaging, such as non-linearity of intensity in FISH and clustering of fluorescence molecules, should also be discussed.



9. Quality control in cell culture and biology experiments

There has recently been significant interest in reproducibility in the biosciences. Cell cultures have been used incorrectly or mis-identified. For example, many cell lines are actually HeLa cells. Western blots have also been manipulated to mis-represent results and issues with antibody specificity and the possible off-target effects have been poorly controlled. Further, the mis-use of statistics has resulted in the reporting of false positives, which are not reproducible later on. The report should highlight common errors and methods to spot data manipulation. Highlight techniques that can be used to identify and avoid such problems in research.

10. Plants vs animals

Many breakthroughs in biology have been made by studying plant growth and development. For example, silencing RNA was first discovered in plants. However, plant biology often does not get the recognition it deserves. Discuss at least three major advances initially discovered in plants that have affected animal research. Further, suggest how the divide between plant and animal researchers can be bridged.

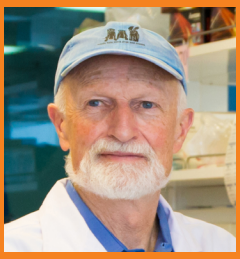
11. Organoids

Organogenesis is a fundamental process in development, yet we know very little about how complex organs form. This is due in part to the experimental inaccessibility of many systems for live imaging. Recently, organoids ("organ in a dish") have been used to study organogenesis and also to potentially provide replacement organs. Discuss the advantages and disadvantages of organoids, and further discuss the relevance to human health.

12. Good bacteria / bad bacteria

We know that a large percentage of our own body mass is formed from other organisms, primarily bacteria. Many of these provide essential services to us and are typically non-toxic. Even in the case of bacteria such as E. coli, the health danger depends on their state (e.g. as biofilms). Discuss recent work on the human microbiome and its importance in understanding human health. Furthermore, outline the role of bacteria inside humans, and when they are advantageous and when they are dangerous.

SPEAKER BIOS



Michael SHEETZ

Principal Investigator, Mechanobiology Institute
Department of Biological Sciences, NUS

Prof. Michael Sheetz is a Distinguished Professor at NUS and Emeritus Professor at Columbia University. He has over 40 years of experience in cell biology and biomechanics, and his seminal work in studying cellular motor functions led to the discovery of a novel class of motor proteins called kinesins. A recipient of several prestigious awards given in recognition of his contributions to biomedical sciences, Prof. Sheetz is a pioneer in the emerging field of mechanobiology. His lab focuses on studying the molecular mechanisms of force sensing and transmission during cell motility.

LIM Chwee Teck

Director, Institute for Health Innovation & Technology (iHealthtech)
Principal Investigator, Mechanobiology Institute
Department of Biomedical Engineering, NUS

Prof. Lim Chwee Teck is a scientist, innovator and entrepreneur. He enjoys tackling problems arising from clinically unmet needs, developing innovative disruptive solutions, and translating them from bench to bedside and market. To date, he and his team has published over 400 journal papers, garnered 100 research awards and honours, and cofounded 6 startup companies.

Antonia MONTEIRO

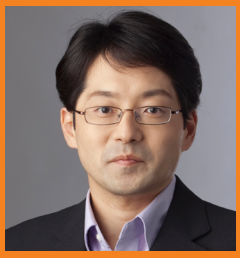
Department of Biological Sciences, NUS
Yale-NUS College

Assoc. Prof. Antonia Monteiro's research group focuses on the origin of morphological novelties and how genes and the environment modify the development of butterfly wing patterns. Her group also addresses how the environment, and especially learning, can impact the evolution of butterfly wing patterns, sex pheromones, and the process of speciation.

Timothy SAUNDERS

Principal Investigator, Mechanobiology Institute
Department of Biological Sciences, NUS

Asst. Prof. Timothy Saunders started his research group at the Mechanobiology Institute in September 2013. His group looks to apply ideas from biophysics to developmental biology. In particular, he focuses on better understanding how complex organ shape arises and when cell fate decisions are taken during development.



Yusuke TOYAMA

Principal Investigator, Mechanobiology Institute
Department of Biological Sciences, NUS

Assoc. Prof. Yusuke Toyama earned a Ph.D. in engineering where his doctoral work was focused on plasma physics. He then embraced biophysics during his postdoctoral training at Duke University while researching embryo development. In May 2010, he joined the Department of Biological Sciences at NUS with a joint appointment at the Mechanobiology Institute. His research interest includes cell and tissue dynamics especially in the context of animal development.

Robert LIEU

Department of Biological Sciences, NUS

Dr. Robert Lieu Zi Zhao is currently a lecturer with the Special Programme in Science (SPS) and the Department of Biological Sciences at NUS, Singapore. Currently, he teaches undergraduate science modules at SPS and the Life Science Curriculum. Also, he is involved in teaching the NUS-ANU Joint Master in Science communication Degree programme. Prior to this, he was a research fellow at the Mechanobiology Institute. His current research interests include areas in science communication (such as public literacy and social media), Synthetic biology and Bioimaging.

MAKHIJA Ekta Parshotam

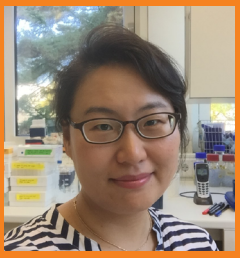
Singapore-MIT Alliance for Research and Technology (SMART)

Dr. Makhija graduated from MBI in 2015 and joined Prof. Van Vliet's group at SMART as a postdoc in 2016. She uses mechanical strain to promote formation of the insulating myelin layer on neurons. Her research on mechanotransduction pathways in oligodendrocytes (glial cells that make myelin) has applications towards repair of damaged myelin in neurodegenerative diseases and ageing.

Roman CARRASCO

Department of Biological Sciences, NUS

Assoc. Prof. Roman Carrasco started the BioEcon lab at the Department of Biological Sciences in 2012. The main research focus of the BioEcon lab gravitates around sustainability science. The lab aims at identifying strategies for the reconciliation of biodiversity conservation, food security, and economic development in the tropics.



Eunyoung CHAE

Department of Biological Sciences, NUS

Asst. Prof. Eunyoung Chae established her Plant Genetics Laboratory in the Department of Biological Sciences, NUS in 2018. The major theme of her lab includes plant immunity and natural variation of the plant immune system. The current focus of the lab is to understand how plants recognize non-self and trigger immune response, and various plant immune receptors are under investigation for their structure and function.

Gregory Jeremiah JEDD

Temasek Life Sciences Laboratory
Department of Biological Sciences, NUS

Gregory Jedd is a Senior Principal Investigator at Temasek Life Sciences Laboratory (TLL) and an Adjunct Associate Professor at the Department of Biological Sciences, NUS. His group develops unconventional model systems to investigate the fundamental mechanisms underpinning cellular growth, development and evolution. More on his research interests can be seen here: gregoryjedd.com.

Pakorn Tony KANCHANAWONG

Principal Investigator, Mechanobiology Institute
Department of Biomedical Engineering, NUS

Assoc. Prof. Tony Kanchanawong is a PI at the Mechanobiology Institute and a faculty member of the Department of Biomedical Engineering since 2011. His research interest focuses on the development and applications of superresolution and advanced microscopy techniques to elucidate nanoscale architecture in cellular structures, and understanding the nanoscale structure-function relationship that underlies how complex molecular machines perform their biological functions, particularly in mechanosensing and mechanotransduction.

Victor KOSTYUCHENKO

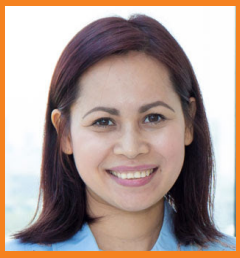
Duke-NUS Medical School, Singapore

Dr. Kostyuchenko is a senior research fellow in the Emerging Infectious Disease Programme at Duke-NUS. He works in Prof. Lok Shee-Mei's Laboratory of Virus Structure and Function. The group explores flaviviruses, such as dengue and zika – their structures, life cycle, and interactions with receptors and antibodies, using electron microscopy as the main tool for structural studies.

Duane LOH

Department of Biological Sciences, NUS

Asst. Prof. Duane Loh Ne-Te started his group in 2016, to develop robust computational optics techniques to recover the structure and dynamics of heterogeneous nanoscale phenomena using noisy and incomplete data from X-ray diffractive imaging and electron microscopy.



Khin Khine Zar MON

Mechanobiology Institute, NUS

Dr. Kai Mon graduated from University of California, Davis in 2018 and joined Professor Linda Kenney's lab at Mechanobiology Institute, NUS as a Postdoctoral Fellow. Her research work focuses on exploring the oncolytic potential of Salmonella Typhimurium using unique in vivo model of the chick embryo chorioallantoic membrane (CAM) system.

Fumio MOTEGI

Principal Investigator, Mechanobiology Institute
Department of Biological Sciences, NUS

Asst. Prof. Fumio Motegi joined the Mechanobiology Institute in August 2012. His group is interested in understanding the mechanics of 1) initiation of cell polarization and 2) spatial patterning of cellular asymmetry in animal development.

Moirangthem Kiran SINGH

Mechanobiology Institute, NUS

Dr. Singh graduated with a Ph.D. in Chemistry where his doctoral work focused on ultrafast and single molecule spectroscopy under Prof. Sobhan Sen of School of Physical Sciences, JNU, India. He is a Research Fellow under Prof Linda Kenney's lab at Mechanobiology Institute, NUS. His research interests focus on understanding bacterial signalling and pathogenesis by applying advanced fluorescence microscopy techniques.

Peter SO

Singapore-MIT Alliance for Research and Technology (SMART)

Prof. Peter So is a faculty member of the Department of Mechanical and Biological Engineering in the Massachusetts Institute of Technology. Prior to joining MIT, he obtained his Ph.D. from Princeton University in 1992 and subsequently worked as a postdoctoral associate in the Laboratory for Fluorescence Dynamics in the University of Illinois in Urbana-Champaign. His research focuses on developing high resolution and high information content microscopic imaging instruments. These instruments are applied in biomedical studies such as performing a non-invasive optical biopsy of cancer, identifying mechanotransduction processes in cardiovascular diseases, and understanding the effects of neuronal remodeling on memory plasticity. Prof. So is currently the Director of the MIT Laser Biomedical Research Center, a NIH NIBIB P41 research resource. He is also a member of the CAMP team in SMART.

Hongyan WANG

Duke-NUS Medical School, Singapore

Assoc. Prof. Hongyan Wang joined Duke-NUS Medical School in 2007 and is the Deputy Director of the Neuroscience & Behavioural Disorders Programme. Her group focuses on understanding brain development and modelling of neurodevelopmental diseases. She is a recipient of the Singapore Young Scientist Award in 2008 and awarded a National Research Foundation (NRF) fellowship in 2009. She is a member of Asia-Pacific Drosophila Board and an Associate Editor of PLOS Genetics.

Christoph WINKLER

Department of Biological Sciences, NUS

Assoc. Prof. Christoph Winkler is an Assistant Head at the Department of Biological Sciences and a member of the Centre for Bioimaging Sciences at NUS. His lab uses zebrafish and medaka models to investigate molecular mechanisms of human diseases, in particular neurodegenerative diseases and osteoporosis.

YAN Jie

Principal Investigator, Mechanobiology Institute
Department of Physics, NUS

Yan Jie is a PI at the Mechanobiology Institute and a professor of the Department of Physics. His research interests focus on the stability and interactions of biomolecules under mechanical constraints.

YEONG Foong May

Department of Biochemistry, NUS

Yeong Foong May is an associate professor of the Department of Biochemistry, Yong Loo Lin School of Medicine. Her research interest focuses on exit from Mitosis, spindle dynamics, and fungal pathogenesis.

Hanry YU

Principal Investigator, Mechanobiology Institute
Department of Physiology, NUS

Prof. Hanry Yu is a PI at the Mechanobiology Institute, faculty member of the Department of Physiology, Co-Lead PI of CAMP IRG in the Singapore-MIT Alliance for Research and Technology, and Group Leader at the Institute of Bioengineering and Nanotechnology, A*STAR. He was trained as a cell biologist but has since ventured into various other disciplines such as imaging, biomaterials, tissue engineering, drug testing, Mechanobiology and computational biology of liver diseases. He takes pride in the interdisciplinary translation approach to research and graduate training; and he strives to build integrated teams to equip future graduates to readily adapt into both industrial and future academic settings. He plays a key role in 6 successful startup companies. He is a handling editor of Biomaterials.

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