香港中文大學理學院
FACULTY OF SCIENCE
THE CHINESE UNIVERSITY OF HONG KONG

SCIENCE FACULTY

RESEARCH DAY 2022

COLLABORATIVE & IMPACTFUL RESEARCH IN SCIENCE

19 MAY THURSDAY | 9:15 AM – 12:45 PM | LIVE ON ZOOM

Science Empowers Your Dreams

PROGRAMME

09:15 - 09:30	**Opening Remarks** ***Professor SONG Chunshan*** Dean of Science
09:30 - 10:15	Keynote Speech: **Collaborations as an Essential Strategy towards High Impact Research** ***Professor QIN Ling*** Choh-Ming Li Professor of Orthopaedics and Traumatology Professor, Department of Orthopaedics and Traumatology, CUHK
10:15 - 10:40	**Towards the Use of Cry3Aa-Enzyme Fusion Crystals for Promoting Electrochemically Driven Enzymatic Reactions** ***Professor CHAN Michael Kenneth*** Professor, School of Life Sciences
10:40 - 11:05	**Third-generation Thin-Film Solar Cell Studies with Grazing-incidence X-ray and Neutron Scattering** ***Professor LU Xinhui*** Associate Professor, Department of Physics
11:05 - 11:15	**Break (10 minutes)**
11:15 - 11:40	**Differential Inference for Single-cell Sequencing Data** ***Professor WEI Yingying*** Associate Professor, Department of Statistics
11:40 - 12:05	**Towards a Comprehensive Understanding of the Sources, Composition and Health Impacts of Organosulfates in Atmospheric Aerosols** ***Professor CHAN Man Nin*** Associate Professor and Director, Earth System Science Programme
12:05 - 12:30	**Risks of Earthquakes Induced by Shale Gas Development in the Sichuan Basin, China** ***Professor YANG Hongfeng*** Associate Professor, Earth System Science Programme
12:30 - 12:45	**Closing Remarks** ***Professor SONG Chunshan*** Dean of Science

Message from the Dean of Science

Welcome to the Faculty of Science Research Day 2022 at The Chinese University of Hong Kong. Every year, the Faculty organises a Research Day where researchers gather to share ideas and experiences in advancing research and collaboration in the Faculty and CUHK. After the soaring fifth wave of COVID-19 pandemic in Hong Kong around Spring 2022, to curb the spread of this pandemic, the Faculty Research Day this year goes virtual again with the theme of "Collaborative and Impactful Research in Science". Although we are not meeting physically in large group this time, we hope the Science Faculty Research Day still serves as a platform to exchange ideas from recent research advances and to encourage collaborative research across different disciplines.

The advantage of collaboration has been recognised widely in many areas, as indicated in a quote from Mother Teresa, "I can do things you cannot, you can do things I cannot; together we can do great things." Collaborative research has become more prevalent in science globally not only because science is a collaborative effort but also because addressing major scientific and societal challenges requires multi-disciplinary research and development. Therefore, researchers are increasingly required to work across disciplines to be more impactful. To align with the CUHK 2021-2025 Strategic Plan and the Faculty research strategy, we have identified seven strategic research areas with pronounced emphasis on inter- and multi-disciplinary research that crosses individual units' boundaries. These approaches are expected to promote multi-disciplinary research and unleash the tremendous potential of our researchers in collaborative research for meeting complex and convoluted challenges to generate more significant research impact.

For the Faculty Research Day this year, we are very pleased to have Prof. Ling QIN, Choh-Ming Li Professor of Orthopaedics and Traumatology from the CUHK Faculty of Medicine as the Keynote Speaker. Prof. QIN has demonstrated track records of highly successful and impactful collaborative research including his leadership to develop competitive research grants and lead multidisciplinary collaboration, including GRF, CRF, TRS and AoE. He will share his insights on his impactful translational research in multidisciplinary collaboration with scientists from diverse fields. Prof. QIN is also the Director of CUHK Hong Kong-Shenzhen Innovation and Technology Research Institute (Futian) (FITRI) in the Lok Ma Chau Loop. His sharing and insights on this aspect will also be very valuable for researchers in Faculty of Science. As a related effort, our faculty members in physics, chemistry and life sciences are involved in new collaborative efforts in developing the CUHK-Great Bay University Joint Institute of Advanced Materials and Green Energy Research (JIAMGER) in Dongguan, for which the MOU has been signed recently by both universities.

The Faculty has started a new seed grant for promoting collaborative research across the disciplinary boundaries in the Faculty, with the support of the CUHK "Project Impact Enhancement Fund (PIEF)" in 2020-2021, which is called the "Faculty of Science Collaborative Research Impact Matching Scheme (CRIMS)". The scheme has been regularised since 2022-2023 with the Faculty budget, to continuously support interdisciplinary collaborative research leading to impactful advances in research with benefits to the society. In this connection, the Research Day this year features the sharing by five colleagues from the Faculty of Science representing collaborative research teams, including Prof. Man Nin CHAN in earth system science, Prof. Michael Kenneth CHAN in life sciences, Prof. Xinhui LU in physics, Prof. Yingying WEI in statistics, and Prof. Hongfeng YANG in earth system science. They will share the highlights of their latest collaborative research projects, supported by CRIMS 2020-2021.

As indicated in a quote from Henry Ford, "Coming together is a beginning, staying together is progress, and working together is success." Over the past ten years, the Faculty has successfully secured 22 Collaborative Research Fund (CRF) projects and 3 Area of Excellence (AoE) projects funded by the Research Grants Council (RGC). Riding on the excellent track record of collaborative research grants, the Faculty strives to promote and support collaborative research across disciplines. It is our hope that the Science Faculty Research Day 2022 will foster the Faculty's initiatives to promote discussion towards collaborative research development between researchers in different disciplines and units and reinforce the multi-disciplinary and impactful collaboration in Science Faculty, CUHK and beyond.

I look forward to a stimulating Research Day with active participation and lively discussion.

Chunshan SONG
Dean of Science and
Wei Lun Professor of Chemistry

Keynote Speech:

Collaborations as an Essential Strategy towards High Impact Research

Professor QIN Ling

Choh-Ming Li Professor of Orthopaedics and Traumatology
Professor, Department of Orthopaedics and Traumatology, CUHK
Director, CUHK Hong Kong-Shenzhen Innovation and Technology Research Institute (Futian)
Director, Innovative Orthopaedic Biomaterials and Drug Translational Research Laboratory of Li Ka Shing Institute of Health Sciences, Faculty of Medicine, CUHK

"The university of the future will be inclusive of broad swaths of the population, actively engaged in issues that concern them, relatively open to commercial influence, and fundamentally interdisciplinary in its approach to both teaching and research." (*Nature* 446(7139): 949, 2007). Research Excellence Framework 2014 (REF 2014) emphasises much on "Impact" where univeristy-industry collaboration is essential.

Research with high impact is definitively important for us to secure competitive research funding, including GRF, CRF, TRS and AoE, where multidisciplinary collaboration is definitively crucial. Professor Ling QIN personally benefited from such collective efforts in both academic aspects and innovation towards clinical translation and he will share some of his collaborative work with material scientists, biomedical engineers, industrial partners, medical doctors, not the last also regulatory bodies in innovation and R&D of biodegradable and bioactive Magnesium-based Class III medical implants for orthopaedic applications, using the approach of "from-bedside-to-bench-to-bedside". Such innovation and collaborative efforts have also been highlighted in *Nature* and *Science*.

The recent development in Greater Bay Area (GBA) and the establishement of CUHK Hong Kong-Shenzhen Innovation and Technology Research Institute (Futian) (FITRI) in the Lok Ma Chau Loop provide new platforms for our further collaboration for innovation and transformation of R&D with high impact. Professor QIN will also introduce and update some recent development of FITRI, including a "block funding" mode been proposed for long-term sustainable development of FITRI in GBA.

Keynote Speaker's Introduction

Professor Ling QIN is Choh-Ming Li Professor of Orthopaedics and Traumatology and Director of CUHK Hong Kong-Shenzhen Innovation and Technology Research Institute (Futian) and Musculoskeletal Research Laboratory of the Department of Orthopaedics & Traumatology, The Chinese University of Hong Kong. Professor QIN has been working on basic and translational research in orthopaedics over the past 30 years and is the past President of the International Chinese Musculoskeletal Research Society (ICMRS) and members of a number of journal editorial boards, including Editor-in-chief of *Journal of Orthopaedic Translation*.

Professor QIN published 9 books and over 360 SCI journal papers with a H-index of 65. Professor QIN has received over 30 competitive research grants, including AoE, TRS, CRF, GRF, ITF, HMRF, NSFC-RGC, and EU-NSFC, 12·5 and 13·5 Key R&D projects of the MOST, as well as over 30 research awards. He also holds over 30 inventions or new utility patents from PRC and USA. Professor QIN received many prestigious honours and awards, including Fellowships of AIMBE, ICORS, ASBMR, and IUSBSE attributed to his contributions to musculoskeletal research and innovation of biomaterials, especially biodegradable and bioactive Magnesium-based Class III medical implants for orthopaedic applications that has also been highlighted recently in *Nature* and *Science*.

Towards the Use of Cry3Aa-Enzyme Fusion Crystals for Promoting Electrochemically Driven Enzymatic Reactions

Professor CHAN Michael Kenneth

Professor, School of Life Sciences

Cry3Aa is a novel protein that naturally forms crystals within the bacterium *Bacillus thuringiensis (Bt)*. We previously discovered that when Cry3Aa is fused to various reporter proteins, the resulting Cry3Aa-reporter fusions still form crystals. We realised that this would be an excellent system for producing immobilized enzyme catalysts, and subsequently reported the use of this technology for the direct immobilization of lipases within bacterial cells – an advance over traditional methods, because the immobilised lipase can be used without column or other affinity purification. In addition to fusing a target lipase to Cry3Aa, we have also shown that co-expression and entrapment of a lipase within the channels of the Cry3Aa protein crystal can be even more effective.

Using the support of the CRIMS grant, we have worked to extend this Cry3Aa enzyme immobilization platform to use in electrochemical biocatalysis. The team was comprised of biochemists who could produce the Cry3Aa enzyme crystals, and chemists who had experience in catalyzing chemical reactions at electrodes. In this presentation, I will describe the initial targets that were pursued, the challenges that were encountered, the progress made, and briefly, the distinct direction that these research efforts led to.

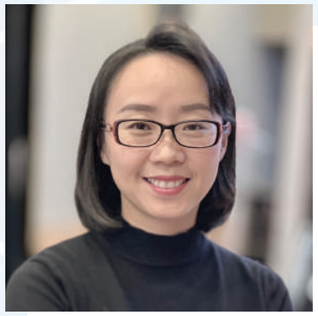
Prof. CHAN obtained his BS in Chemistry from Harvey Mudd College where he worked on organometallic complexes, and his PhD in Chemistry from UC Berkeley where he worked on the synthesis of bioinorganic model compounds of the manganese oxygen evolving complex of PS II. His postdoctoral studies were performed with Prof. Doug Rees at Caltech where he learned to use protein crystallography to determine the structures of molybdenum and tungsten containing proteins. Michael began his independent position at The Ohio State University where he continued his interest in elucidating the structures of metalloenzymes and other proteins. There he solved the first structures of a heme sensing domain, and the methanogenic nickel-containing carbon monoxide dehydrogenase. He is arguably best known, however, for his co-discovery of pyrrolysine, the 22nd genetically-encoded amino acid in nature from the structure of the *Methanosarcina barkeri* monomethylamine methyltransferase. In addition to elucidating its structure, this finding led him to undertake research focused on using the pyrrolysine system to incorporate unnatural amino acids into proteins which remains one of his major focus areas today. After moving to The Chinese University of Hong Kong, Michael's group initiated a novel research area focused on using natural protein crystals produced by the bacterium *Bacillus thuringiensis*. They have demonstrated that these crystals can be used as a platform for efficient delivery of protein therapeutics, as well as a novel scaffold for the direct immobilisation of enzymes for biocatalysis. The current presentation is based on these latter studies.

Third-generation Thin-Film Solar Cell Studies with Grazing-incidence X-ray and Neutron Scattering

Professor LU Xinhui

Associate Professor, Department of Physics

Nowadays, solar industry becomes the fastest growing industry due to the rising demands to solve energy crisis and environmental problems. Third generation solar cells such as organic and perovskite solar cells are all relying on a semiconducting thin-film active layer to harvest the solar energy. The bulk morphology of the active layer in terms of crystal structure, orientation, grain size and nanophase separation behaviors is known to be critical to the solar cell device performance. Here, we will present our recent studies on the process-structure-device correlation of organic and perovskite solar cells. In these studies, state-of-the-art grazing incidence scattering techniques X-rays and neutrons were employed for various purposes, such as grazing incidence wide-angle/small-angle X-ray scattering (GIWAXS/GISAXS), grazing incidence transmission small-angle X-ray scattering (GTSAXS), grazing incidence neutron scattering (GISANS). These techniques can also be applied in material science, chemistry, biology and condensed matter physics studies. By modifying the wavelength of the probing beam and the experimental geometry, a variety of sample types, such as solutions, powders, surfaces and thin films, can be studied, covering wide length scales as well as versatile dynamic and kinetic behaviors.



Prof. LU is an associate professor in the Department of Physics, The Chinese University of Hong Kong. She received her bachelor's degree from Nanjing University and PhD degree from Yale University. Then, she worked as a postdoctoral research associate at Brookhaven National Laboratory before joining CUHK. Her research interest lies in energy related material science and experimental soft condensed matter physics, including morphology and device performance of organic and perovskite photovoltaic materials, bulk and surface structure of functional thin films and synchrotron x-ray scattering techniques. She is now serving as the council member of Physical Society of Hong Kong and Chinese Neutron Scattering Society.

Differential Inference for Single-cell Sequencing Data

Professor WEI Yingying

Associate Professor, Department of Statistics

Single-cell sequencing technologies enable us to measure the genome, epigenome and transcriptome of individual cells. Thus, by providing the unprecedented opportunities to investigate biological systems at the resolution of cells, single-cell sequencing technologies have revolutionised many fields of biomedical research. Nevertheless, the analysis of single-cell sequencing data is very challenging. Single-cell sequencing data are well known for suffering from large data volume, severe technical artifacts, high noise levels, and sparse signals with many dropout events—a gene is actually expressed but its observed value is zero. In the past several years, there has been very active research on batch effects correction, cell type clustering, and missing data imputation for single-cell sequencing data. However, although single-cell sequencing experiments are becoming more and more complicated with multiple treatments or biological conditions, statistical methods to compare single-cell sequencing data collected from different conditions are still lacking. In this talk, we will present our recently developed statistical method that is able to rigorously quantify the treatment effects on both cellular compositions and cell-type-specific gene expression levels for single-cell RNA-seq data. We demonstrate the performance of our method with a publicly available pancreatic study as well as single-cell sequencing data collected from developmental systems by our colleagues in the School of Life Sciences.

Prof. WEI is an associate professor in the Department of Statistics, The Chinese University of Hong Kong. She obtained her bachelor's degree in Mathematics from Tsinghua University in 2009 and her MSc Eng degree in Computer Science and PhD degree in Biostatistics from Johns Hopkins University in 2014. Her research focuses on developing statistical methods for analysing noisy, complex and heterogeneous big genomic data. Her six Bioconductor R packages have been well received by the community, with more than 69,000 downloads to date. Prof. WEI received the Faculty Exemplary Teaching Award from the Faculty of Science, CUHK in 2017 and the W. J. Youden Award in Interlaboratory Testing from the American Statistical Association in 2019.

Towards a Comprehensive Understanding of the Sources, Composition and Health Impacts of Organosulfates in Atmospheric Aerosols

Professor CHAN Man Nin

Associate Professor and Director, Earth System Science Programme

Traditionally inorganic sulfate has been assumed the most important form of aerosol sulfur. However, recent field measurements have detected a significant contribution to aerosol sulfur from organic sulfur sources, which increasing evidences indicate that the latter could alter the physicochemical properties of atmospheric aerosols and play a role in regional air quality and global climate. Organosulfates ($R–OSO_3^-$) have been identified a major class of atmospheric organosulfur compounds. Primarily existing in aerosol phase, many structurally-different organosulfates remain uncharacterised in respects of their formation and transformation pathways under atmospheric conditions, and more crucially, the potential toxicity through inhalation. Hong Kong and the Pearl River Delta (PRD) region have very active biogenic and anthropogenic activities, making the places favorable for the formation of organosulfates from different volatile organic compounds (VOCs) precursors (e.g. isoprene (C_5H_8), monoterpenes ($C_{10}H_{16}$), and aromatics) under the influence of anthropogenic emissions (e.g. sulfur dioxides (SO_2) and nitrogen oxides (NO_X)). In particular, certain organosulfates (e.g. aromatic organosulfates) may potentially pose health threats in urban environments. This collaborative project aims to 1) identify and quantify the key factors and processes governing the formation, composition, and abundance of organosulfates in atmospheric aerosols in Hong Kong and PRD region via laboratory investigations, field campaigns, and model simulations; 2) dissect the potential biological responses triggered by inhalation of organosulfates in atmospheric aerosols; 3) to develop a state-of-the-art air quality model to predict and assess the abundance and health impacts of atmospheric organosulfates. Collectively, this study aims to achieve a thorough understanding of how organosulfates in atmospheric aerosols form, evolve, and impact our environment and health. This talk will present the research progress and achievements of this collaborative project.

Prof. CHAN is an associate professor and Director in the Earth System Science Programme, Faculty of Science at The Chinese University of Hong Kong. His research area is ambient air pollution, focusing on the sources and formation mechanisms of particulate matter (PM). His research group applies novel analytical techniques coupled with high resolution mass spectrometers to investigate the composition and transformation of PM in the atmosphere, such that we can better understand their sources, environmental, and health impacts. Prof. CHAN received his PhD in Environmental Science and Engineering at California Institute of Technology. Prior to joining CUHK, he was a postdoctoral fellow in the Chemical Science Divisions at Lawrence Berkeley National Laboratory.

Risks of Earthquakes Induced by Shale Gas Development in the Sichuan Basin, China

Professor YANG Hongfeng

Associate Professor, Earth System Science Programme

In the past decade, significant efforts have been made in developing new energy resources to meet the globally growing demand. However, the anthropogenic processes associated with new energy development may cause earthquakes, termed induced earthquakes. One scenario is related to shale gas development, which was boomed in late 1990s because hydraulic fracturing (fracking), an innovative technique to inject high-pressure fluids and stimulate fracture growth in the low-permeability shale reservoir, had been extensively used in various countries. As one of the major shale gas blocks in China, the Weiyuan shale gas field has been actively developed since 2010, accompanying numerous fracking activities. Accordingly, the number of earthquakes has been increasing drastically, with a few damaging earthquakes (M>4) since 2019, some of which led to fatalities. However, it remains unclear how these earthquakes might have been induced. We derived high-resolution tomographic structure and earthquake location using data recorded at dense arrays. High-resolution locations of seismicity exhibit clear lineation and temporal migration parallel to the horizontal wells, indicating a causal relationship. Most earthquakes are concentrated near the depth of fracking. However, the largest earthquakes occur on basement faults, 3 km below the injection layer. In comparison, one deadly earthquake struck above the injection layer at 1-km depth that had long been considered aseismic, challenging our traditional view of earthquake mechanics. Our high-resolution source parameters indicated a mixture of mechanisms that can induce earthquakes in the region, providing critical insights for hazard assessment of induced earthquakes in the Sichuan Basin.

Prof. YANG joined The Chinese University of Hong Kong in 2014 and is now an associate professor in the Earth System Science Programme. He is actively working on earthquake source physics, subduction zone dynamics, fault zone structure and evolution, and induced earthquakes. He is a committee member in several committees in Chinese Geophysical Society and Chinese Seismological Society, and serves in the editorial board for several journals and as an associate editor for *Seismological Research Letters*. In 2018, Prof. YANG received the *Fu Chengyi* Young Scientist Award, in recognition of his contributions to integrating earthquake rupture dynamics and observational seismology to advance our understanding of earthquake physics and seismic hazard evaluation. Prof. YANG is the first recipient of this prestigious award from Hong Kong.

香港中文大學理學院
FACULTY OF SCIENCE
THE CHINESE UNIVERSITY OF HONG KONG