大學教育資助委員會
University Grants Committee

香 港 大 學
THE UNIVERSITY OF HONG KONG

TRS
Public Symposium 2022
主題研究計劃研討會

Research Grants Council
研究資助局

Theme-based Research Scheme Public Symposium 2022
主題研究計劃研討會

December 11, 2022 (Sunday)
9:00 am – 4:00 pm

Lecture Theatres T1 and T2,
Meng Wah Complex,
The University of Hong Kong

2022年12月11日 (星期日)
上午9時至下午4時

香港大學明華綜合大樓
1號講堂及 2號講堂

Table of Contents
目錄

Message from Chair of Research Grants Council
研究資助局主席歡迎辭

On behalf of the Research Grants Council, I welcome you to the Theme-based Research Scheme (TRS) Public Symposium 2022.

Since 2011, TRS has been providing huge support for University Grants Committee-funded universities to conduct research on themes of strategic importance to the long-term development of Hong Kong. A total funding of $2.7 billion was granted to 68 projects in the past twelve rounds of exercise. 12 projects funded in the sixth and seventh rounds have been successfully completed or are approaching completion. We are delighted to have the project teams to share with us today, through presentations, posters display and demonstrations, the achievements and novel discoveries and impacts of their frontier research.

Taking this opportunity, I would like to express my sincere gratitude to members of the 12 project teams and their universities for their contributions in making this Symposium a success. I would also like to thank Research Services of The University of Hong Kong for organising the Symposium physically for the first time since the pandemic.

We look forward to seeing the impacts brought by these TRS projects benefitting the social and economic development of Hong Kong.

Professor Yuk-shan Wong
Chair
Research Grants Council

我謹代表研究資助局，歡迎大家參加主題研究計劃研討會 2022。

自 2011 年以來，主題研究計劃一直大力支持大學教育資助委員會資助大學，對香港長遠發展具策略重要性的主題進行研究。在過去十二輪計劃中，總共向 68 個項目批出 27 億元撥款。在第六及第七輪獲得撥款的十二個項目已成功完成或進入最後階段。我們很高興項目團隊今天將透過講座、海報及展覽，與我們分享他們的前沿研究成果、嶄新發現及影響。

藉此機會，我衷心感謝十二個項目的團隊成員和他們所屬的大學對是次研討會的支持，使研討會得以成功舉行。我亦感謝香港大學的科研事務部自疫情以來首度恢復籌辦實體研討會。

我們期望這些主題研究計劃項目帶來的影響，使香港的社會和經濟發展深受得益。

研究資助局主席
黃玉山教授

About the Theme-based Research Scheme
主題研究計劃概要

Theme-based Research Scheme (TRS) aims to focus academic research efforts of University Grants Committee funded universities on themes of strategic importance to the long-term development of Hong Kong.

There are four designated research themes under the TRS. Under the four research themes, there are 20 grand challenge topics. The themes and grand challenge topics are as follows:

Theme 1 Understanding Diseases and Disease Prevention

1. Infectious Diseases
2. Understanding Disease Mechanisms to Improving Health
3. Stem Cells and Regenerative Medicine
4. Disease Prevention and Management

Theme 2 Developing a Sustainable Environment

1. Water Pollution and Water Treatment
2. Sustainable Built Environment
3. Energy Efficiency, Conservation, Conversion and Harvesting
4. Air Quality
5. Food Production and Food Security

Theme 3 Enhancing Hong Kong's Strategic Position as a Regional and International Business Centre

1. Hong Kong's Future as an International Financial Centre
2. Promoting Hong Kong's Business through Networking Capability
3. Promoting Hong Kong as a Centre of Excellence for Business Services
4. Innovation Ecology and Business Creation in Knowledge Economy
5. Financial Technologies (FinTech) and Regulatory Technologies (RegTech)

Theme 4 Advancing Emerging Research and Innovations Important to Hong Kong

1. Big Data and Artificial Intelligence
2. Imaging, Robotics and Smart Manufacturing
3. Urban Infrastructure and Smart City
4. Education and Digital Citizenship
5. Quantum Technology
6. Integrated Circuits

The maximum duration of a project is five years. The ceiling of direct project cost per project to be awarded by the Research Grants Council is $75 million.

主題研究計劃的目的是集中大學教育資助委員會資助大學的學術研究力量，對香港長遠發展具策略重要性的主題進行研究。

主題研究計劃設有四個研究主題，四個主題下共設有 20 個重大挑戰題目：

主題 一 剖析疾病及疾病預防

1. 傳染病
2. 剖析發病機制以保障健康
3. 幹細胞與再生醫學
4. 疾病預防與管理

主題 二 建設可持續發展的環境

1. 水污染及水處理
2. 可持續建築環境
3. 能源效率、節約、轉化及採集
4. 空氣質素
5. 食物生產及食物安全

主題 三 加強香港作為地區及國際商業中心的策略地位

1. 香港作為國際金融中心的未來發展
2. 透過網絡能力推動香港商業發展
3. 推廣香港成為卓越的商業中心
4. 知識經濟中的創新生態與商業創意
5. 金融科技及監管科技

主題 四 促進對香港起重要作用的新興研究及創新項目

1. 大數據及人工智能
2. 造像、機械人技術及智能製造
3. 城市基礎建設及智慧城市
4. 教育及數碼公民身分
5. 量子技術
6. 集成電路

每個項目的年期最長為五年，研究資助局資助金額上限為 7 千 5 百萬元（按直接項目成本計算）。

Programme *

Date: **December 11, 2022 (Sunday)**

Venue: **Lecture Theatres T1 and T2, Meng Wah Complex, The University of Hong Kong**

THEME 1 Understanding Diseases and Disease Prevention

THEME 2 Developing a Sustainable Environment

THEME 4 Advancing Emerging Research and Innovations Important to Hong Kong

Time	Programme	
9:00 – 9:15	**Opening Ceremony (by Chair of Research Grants Council)** Professor Yuk-shan WONG	
9:15 – 9:45	**Plenary Session - Funding Mechanism of TRS (by Chair of Collaborative Research Projects Steering Committee)** Professor Paul KL YU	
	LECTURE THEATRE T1	**LECTURE THEATRE T2**
9:45 – 10:30	THEME 1 - A1 **Plasma DNA as a Platform Technology for Cancer Detection** **Professor Dennis Yuk-ming LO** *The Chinese University of Hong Kong*	THEME 2 - B1 **Diagnosis and Prognosis of Intensifying Eutrophication, Hypoxia and the Ecosystem Consequences around Hong Kong Waters: Coupled Physical-biogeochemical-pollution Studies** **Professor Jianping GAN** *The Hong Kong University of Science and Technology*
10:30 – 11:15	THEME 1 - A2 **Understanding Cancer Stemness in Liver Cancer – From Regulation to Translational Applications** **Professor Irene Oi-lin NG** *The University of Hong Kong*	THEME 2 - B2 **Enhanced Separation and Sludge Refinery for Wastewater Treatment – Solving the Nexus of Pollution Control and Resource Recovery in Mega Cities** **Professor Xiao-yan LI** *The University of Hong Kong*
11:15 – 11:30	**Tea Break**	
11:30 – 12:15	THEME 1 - A3 **Gastric Cancer Genomics and Beyond – Moving from Patient Samples to 3D Organoid Cultures for Integrative Genomics Analysis, Drug Sensitivity Assays, Cell Biological Studies and Animal Models** **Professor Suet-yi LEUNG** *The University of Hong Kong*	THEME 2 - B3 **Creation of Rechargeable Electron-fuels for Stationary Power Supplies and Electric Vehicles** **Professor Minhua SHAO** *The Hong Kong University of Science and Technology*
12:15 – 13:00	THEME 1 - A4 **Translational Studies for Elucidating the Tumor Heterogeneity and Molecular Evolution in Metastatic Gastrointestinal Tract Cancers for Personalized Medicine** **Professor Simon Ying-kit LAW** *The University of Hong Kong*	THEME 2 - B4 **Photochemical Air Pollution in Highly Urbanized Subtropical Regions: From Micro Environments to Urban-terrestrial-oceanic Interactions** **Professor Tao WANG** *The Hong Kong Polytechnic University*
13:00 – 14:30	**Lunch Break**	
14:30 – 15:15	THEME 1 - A5 **Functional Bone Regeneration in Challenging Bone Disorders and Defects** **Professor Ling QIN** *The Chinese University of Hong Kong*	THEME 4 - B5 **A Compact System for Terahertz Imaging and Spectroscopy** **Professor Chi-hou CHAN** *City University of Hong Kong*
15:15 – 16:00	THEME 4 - A6 **Big Data for Smart and Personalized Air Pollution Monitoring and Health Management** **Professor Victor On-kwok LI** *The University of Hong Kong*	THEME 4 - B6 **Learning and Assessment for Digital Citizenship** **Professor Nancy Wai-ying LAW** *The University of Hong Kong*

*Theme-based Research Scheme projects showcased in Public Symposium 2022 are funded by the Research Grants Council in the Sixth and Seventh Round exercises from 2016/17 to 2017/18.

研討會程序*

日期：2022 年 12 月 11 日（星期日）

地點：香港大學明華綜合大樓 1 號及 2 號講堂

主題一　剖析疾病及疾病預防

主題二　建設可持續發展的環境

主題四　促進對香港起重要作用的新興研究及創新項目

時間	程序	
9:00 – 9:15	**開幕致詞：研究資助局主席** 黃玉山教授	
9:15 – 9:45	**主題研究計劃撥款機制簡介：協作研究項目督導委員會主席** 余劼離教授	
	1 號講堂	**2 號講堂**
9:45 – 10:30	主題一 - A1 **血漿脫氧核糖核酸作為癌症檢測的平台** 盧煜明教授 *香港中文大學*	主題二 - B1 **香港及鄰近海域富營養化，缺氧及生態後果的診斷和預測：物理 - 生物地球化學 - 污染耦合研究** 甘劍平教授 *香港科技大學*
10:30 – 11:15	主題一 - A2 **了解肝癌腫瘤的幹細胞特性：從調節機制到轉化應用** 吳呂愛蓮教授 *香港大學*	主題二 - B2 **高效濃縮分離和污泥精煉協同新技術實現城市水污染控制和資源回收** 李曉岩教授 *香港大學*
11:15 – 11:30	**小休**	
11:30 – 12:15	主題一 - A3 **胃癌基因組學與發展：以病人活組織培養三維類器官細胞團作整合性基因組分析、藥物敏感測定、細胞生物學及動物模型研究** 梁雪兒教授 *香港大學*	主題二 - B3 **用於可再生能源供電站及電動汽車的電燃料儲能技術基礎研究** 邵敏華教授 *香港科技大學*
12:15 – 13:00	主題一 - A4 **闡明轉移性胃腸道癌細胞的異質性和分子進化過程以促進其個體化醫療的研究** 羅英傑教授 *香港大學*	主題二 - B4 **亞熱帶城市群區域大氣光化學污染：從微環境到城市 - 陸地 - 海洋的相互作用** 王韜教授 *香港理工大學*
13:00 – 14:30	**午膳**	
14:30 – 15:15	主題一 - A5 **難愈骨疾病和骨缺損的功能性再生研究** 秦嶺教授 *香港中文大學*	主題四 - B5 **用於太赫茲光譜和成像的小型化系統設計** 陳志豪教授 *香港城市大學*
15:15 – 16:00	主題四 - A6 **大數據為本智能及個人化空氣污染監測和健康管理** 李安國教授 *香港大學*	主題四 - B6 **數碼世代公民素養的學習和評估** 羅陸慧英教授 *香港大學*

* 本研討會所有研究項目均為研究資助局在第六輪（2016/17 年度）和第七輪（2017/18 年度）主題研究計劃撥款資助的項目。

Plasma DNA as a Platform Technology for Cancer Detection
血漿脫氧核糖核酸作為癌症檢測的平台

T12-401/16-W

Project Coordinator 項目統籌人
Professor Dennis Yuk-ming LO 盧煜明教授
The Chinese University of Hong Kong 香港中文大學

Participating Institution 參與院校
The University of Hong Kong 香港大學

Professor Dennis LO and his research team
盧煜明教授及其研究團隊

Short Biography of Project Coordinator 項目統籌人簡介

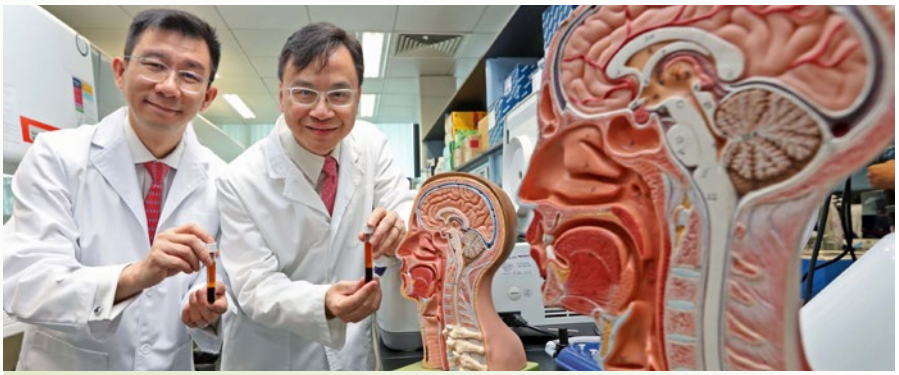
Professor Dennis Yuk-ming LO discovered the presence of cell-free fetal DNA in maternal plasma and developed a novel approach for non-invasive prenatal testing (NIPT) which has now been widely adopted throughout the world. Concurrently, Professor LO and his team extend the concept to cancer diagnostics and take a leading role in the field. He has won multiple prestigious international awards, including the inaugural Future Science Prize in Life Sciences in China, the 2022 Lasker-DeBakey Clinical Medical Research Award, the 2021 Breakthrough Prize in Life Sciences and the 2021 Royal Medal in Biological Sciences by the Royal Society of London. In addition, Professor LO was named as one of the Top 20 Translational Researchers of 2020, published by *Nature Biotechnology* of USA. It is the fifth consecutive year for Professor LO to receive this honour.

盧煜明教授發現孕婦血漿中含有胎兒游離 DNA，並開發了一種無創產前檢測 (NIPT) 方法，該方法現已於世界各地被廣泛採用。同時，盧教授和他的團隊將相關概念擴展至癌症診斷，並在該領域發揮主導作用。他曾獲得多項國際知名獎項，包括中國首屆「未來科學大獎 – 生命科學獎」、2022 年「拉斯克獎—臨床醫學研究」、2021 年「科學突破獎 – 生命科學獎」及 2021 年英國皇家學會生物科學「皇家獎章」。此外，盧教授亦連續五年獲世界權威科學期刊《自然生物科技》選為「全球 20 位頂尖轉化研究科學家」。

Project Summary 項目概要

- Professor LO and the team have developed novel approaches of genomic and methylomic analysis of cell-free nucleic acids to enhance the diagnostic performance of cancer detection. Specifically, a novel assay for nasopharyngeal cancer screening based on the molecular analysis of plasma Epstein-Barr virus DNA is now available for clinical use, with a substantial improvement in the diagnostic performance compared to the conventional method.
- New insights into the fragmentation biology of circulating DNA were generated. The team has uncovered the roles of different nucleases in the fragmentation of circulating DNA and developed a number of 'fragmentomics' markers of circulating DNA, including fragment size, preferred ends and end motifs.
- Through the various molecular approaches including the epigenetics, fragmentomics and topologic analysis of cell-free nucleic acids, the tissue of origin of malignancy could be determined with diagnostic implications.

- 盧煜明教授及其研究團隊開發了嶄新的游離核酸基因組和甲基化分析方法，以提高癌症檢測的診斷效能。具體來說，一種透過分子分析血漿內 Epstein-Barr 病毒 DNA 的新鼻咽癌篩查方法現已可用於臨床診斷，較傳統篩查方法在診斷效能方面有顯著提升。
- 研究團隊對循環 DNA 的片段化產生新見解。他們揭示了不同核酸酶在循環 DNA 片段化中的作用，並開發了一些循環 DNA 的「片段組學」標記，包括片段大小、偏好片段末端和末端序列。
- 研究團隊亦通過各種分子學方法，包括游離核酸的表觀遺傳學、片段組學和拓撲分析，提供惡性腫瘤起源組織資料，具有診斷意義。



Professor Dennis LO and the team have demonstrated for the first time that circulating DNA analysis could achieve early cancer detection using the nasopharyngeal cancer model
盧煜明教授及其研究團隊運用了鼻咽癌模型，第一次展示出透過分析循環 DNA 可以實現早期癌症檢測

Abstract 項目簡介

Liquid biopsy, which is referred as the analysis of various cancer-derived biomarkers in blood or other body fluids, provides an avenue to delineate tumour characteristics non-invasively in contrast to the conventional tumour tissue biopsy. The team has developed different novel approaches of molecular analysis of circulating nucleic acids to enhance the applications in cancer diagnostics. Novel insights into the biology of circulating nucleic acids have been obtained and would facilitate clinical translation.

與傳統腫瘤組織活檢相異，液體活檢技術透過分析血液或其他體液中各種由癌症衍生的生物標記，從而提供一種非侵入性描繪腫瘤特徵的途徑。研究團隊開發了不同創新的循環核酸分子分析方法，以增強於癌症診斷中的應用。團隊亦獲得對循環核酸生物學的新見解，以促進轉化相關技術至臨床診斷。

Research Impact 研究影響

Professor LO and the team were the first to demonstrate that circulating DNA analysis could achieve early cancer detection using the nasopharyngeal cancer model. A large-scale prospective study has been conducted to establish the role of plasma Epstein-Barr virus DNA for screening of nasopharyngeal cancer. This work was published in the top clinical journal, the *New England Journal of Medicine*, and was selected as one of the ten most notable articles in that year, in recognition of the clinical impact.

The patent portfolios that cover the novel technologies for cancer diagnostics developed by the team are valuable. The patent portfolios have been licensed to various industrial partners to realize the commercial value, including Grail, one of the largest liquid biopsy start-up companies in the world.

In addition, these novel technologies have served as a catalyst for building up local talent pool. The start-up company Take2 cofounded by the team members, has started to provide the nasopharyngeal cancer screening service in Hong Kong through licensing the technology developed in this project. Take2 targets to extend the testing service to the Greater Bay Area.

盧教授及其研究團隊運用了鼻咽癌模型，首次展示出透過分析循環 DNA 可以實現早期癌症檢測。經過進行一項大規模的前瞻性研究，團隊已確立血漿中 Epstein-Barr 病毒 DNA 在鼻咽癌篩查中所擔當的角色。這項研究已於頂級臨床期刊《新英倫醫學雜誌》中發表，並獲選為當年十篇「最矚目研究文章」之一，以表彰該研究為臨床應用所帶來的影響。

研究團隊所開發的一系列涵蓋癌症診斷新技術的專利有重要價值。相關專利組合已授權予各工業合作夥伴以實現其商業價值，包括全球最大的液體活檢技術初創公司之一，Grail。

此外，這些新技術也成為建立本地人才庫的催化劑。由團隊成員共同創辦的初創公司 Take2，已開始通過授權相關項目所開發的技術在香港提供鼻咽癌篩查服務。Take2 的目標是將該檢測服務擴展至大灣區。

The study "Analysis of Plasma Epstein–Barr Virus DNA to Screen for Nasopharyngeal Cancer" led by Professor Dennis LO was among the ten most "Notable Articles of 2017" selected by *The New England Journal of Medicine* (NEJM)
由盧煜明教授領導的項目《Analysis of Plasma Epstein–Barr Virus DNA to Screen for Nasopharyngeal Cancer》獲《新英倫醫學雜誌》選為十篇「2017 年度最矚目研究文章」之一

Professor Dennis LO received the inaugural 'Future Science Prize-Life Science Prize' in China
盧煜明教授獲頒中國首屆「未來科學大獎 – 生命科學獎」

Inventor/current university	Total patents granted, 2020
Zhang, Feng/MIT, USA	34
Şahin, Uğur/TRON- Translational Oncology at the University Medical Center of the Johannes Gutenberg University Mainz, Germany[a]	31
Langer, Robert S./Massachusetts Institute of Technology, USA	31
Church, George M./Harvard University, USA	23
Doudna, Jennifer A./University of California, Berkeley, USA[b]	22
Weissman, Irving L./Stanford University, USA	20
Lo, Yuk Ming Dennis and Chiu Wai-kwun, Rossa/Chinese University of Hong Kong, China	18
Vogelstein, Bert and Kinzler, Kenneth W./Johns Hopkins University	17
Gray, Nathanael S./Stanford University, USA	17
Wilson, James M./University of Pennsylvania, USA	16
Ju, Jingyue/Columbia University, USA	16
Weitz, David A./Harvard University, USA	15
Ingber, Donald E./Harvard University, USA	15
Chan, Kwan Chee/Chinese University of Hong Kong, China	15
June, Carl H./University of Pennsylvania, USA	14
Gao, Guangping/University of Massachusetts, USA	14
Markovic, Svetomir N./Mayo Foundation, USA[c]	13
Xia, Ningshao/Xiamen University, China	12
Liu, David R./Harvard University, USA	12
Ring, Aaron M./Yale University, USA[c]	11

Professor Dennis LO, Professor Rossa CHIU and Professor Allen CHAN from the project team have been named among the "Top 20 Translational Researchers of 2020" by the world-renowned scientific journal Nature Biotechnology
團隊成員盧煜明教授、趙慧君教授及陳君賜教授獲世界權威科學期刊《自然生物科技》選為「2020 年全球 20 位頂尖轉化研究科學家」

Understanding Cancer Stemness in Liver Cancer – From Regulation to Translational Applications

了解肝癌腫瘤的幹細胞特性：從調節機制到轉化應用

T12-704/16-R

Project Coordinator 項目統籌人

Professor Irene Oi-lin NG 吳呂愛蓮教授

The University of Hong Kong 香港大學

Participating Institutions 參與院校

The Chinese University of Hong Kong 香港中文大學

The Hong Kong University of Science and Technology 香港科技大學

The Hong Kong Polytechnic University 香港理工大學

Short Biography of Project Coordinator 項目統籌人簡介

Professor Irene NG is currently a Professor and Chair in Pathology in the Department of Pathology and Loke Yew Professor in Pathology at The University of Hong Kong. She is also the Director of the State Key Laboratory of Liver Research. Her research is on the molecular pathogenesis of liver cancer (hepatocellular carcinoma, HCC), identification of liver cancer stem cells and characterization of cancer stemness. Professor NG has published more than 440 peer-reviewed journal articles. She is the Top 1% of most cited scientists in 'Clinical Medicine' of Institute for Scientific Information Essential Science Indicators (ESI) for consecutive 12 years since 2009.

吳呂愛蓮教授是香港大學病理學講座教授、陸佑基金教授（病理學）及肝病研究國家重點實驗室主任。吳教授致力研究肝癌分子發病機制、鑑定新的肝癌幹細胞，以及識別肝癌幹性的表徵。吳教授於國際學術期刊發表逾 440 篇論文，更自 2009 起連續 12 年榮獲“基本科學指標資料庫 "（臨床醫學）首 1% 最高引用次數的科學家。

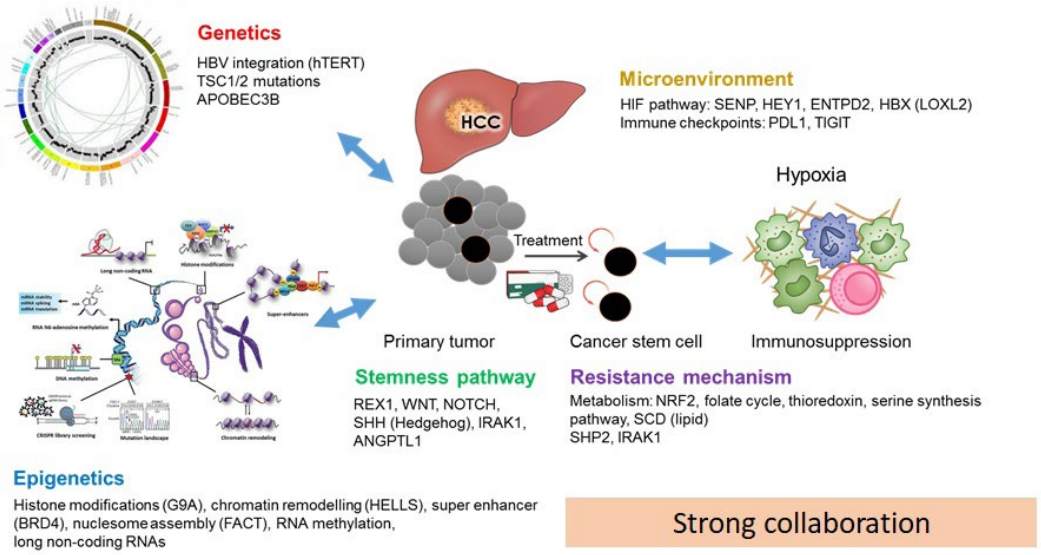
Project Summary 項目概要

Liver cancer is a major burden to social health. It is a common malignancy worldwide and very prevalent in China including Hong Kong, due to the high prevalence of HBV infection. This theme-based research project has addressed the following research questions:

- The regulation of liver cancer stemness and liver cancer stem cells and the molecular mechanisms
  - identified key therapeutic targets and biomarkers as targets for treatment
- The cellular and immunosuppressive landscapes from single cell analysis
  - identified mechanisms and provided targets for novel immunotherapy treatment
- The interaction among tumor microenvironment, liver cancer cells, and cancer stemness
  - provided therapeutic targets

肝癌為社會健康帶來沉重負擔。肝癌是肆虐全球的疾病，由於乙型肝炎的流行，在中國（包括香港）尤其普遍。本主題研究項目針對以下研究議題：

- 肝癌幹性和肝癌幹細胞的調控及其分子機制
  - 確定關鍵治療靶點和生物標誌物作為治療目標
- 透過單細胞分析方法了解細胞和免疫抑制情況
  - 為新型免疫療法確定機制及提供靶點
- 腫瘤微環境、肝癌細胞和癌症幹性之間的相互作用
  - 提供治療靶點



Programme Overview
研究項目概覽

Abstract 項目簡介

Liver cancer is a common malignancy worldwide and very prevalent in China including Hong Kong and a major burden to social health. It is an aggressive cancer, often inoperable and has a high rate of recurrence even after surgical resection and frequent metastasis.

We established a multi-disciplinary program to contribute to addressing this major issue. We have identified many key therapeutic targets and their molecular mechanisms regulating cancer stemness, hence providing targets for selective blocking of these functions. We have also dissected the cancer stemness and immune landscapes using single cell transcriptomic analysis. As cancer cells are maintained in a specialized niche microenvironment, we have delineated the tumor microenvironmental factors in the regulation of liver cancer stemness and identified new mechanisms, including the underlying immunotherapy, which is the now first line drug treatment for advanced liver cancer, and the resistance mechanisms.

Through these studies, we have provided a better understanding of liver cancer stemness and identified potential targets and rationale for treatment.

This program is an inter-disciplinary collaborative project involving The University of Hong Kong, the Chinese University of Hong Kong, the Hong Kong University of Science and Technology and the Hong Kong Polytechnic University. It provides high quality research, trains the next generation of scientists, and helps maintain and enhance Hong Kong's world-leading status in liver cancer research.

肝癌是肆虐全球的疾病，在中國（包括香港）尤其普遍，為社會健康帶來沉重負擔。肝癌具有侵略性，難以手術治療，癌症轉移特別常見，而且手術切除後復發率非常高。

本項目正是一個跨學科計劃以解決此重大問題。研究團隊確定了多個關鍵治療靶點及其調控癌症幹性的分子機理，從而為選擇性阻斷肝癌幹細胞的功能提供靶點。另外，我們利用單細胞轉錄組測序技術，去分析癌症幹性和免疫情況。由於癌細胞處身於一個獨特的微生態環境，我們闡述了腫瘤微環境因素對肝癌幹細胞的調控情況，並確定了新的機制，包括目前用於治療晚期肝癌的一線藥物治療的免疫療法，以及其耐藥機制。

通過這些研究，我們對肝癌幹性有更深入的了解，並確定了治療的潛在靶點和基本原理。

本項目是由香港大學、香港中文大學、香港科技大學及香港理工大學多個院校共同協作的跨學科研究項目。我們的研究著重質量，亦是培養未來科學家的平台，有助保持和提升香港在肝癌研究方面的世界領先地位。

Research Impact 研究影響

Professor NG and the team have:

- Identified key therapeutic targets and biomarkers to guide precision medicine for liver cancer.
- Established the first single-cell RNA-sequencing HCC patient cohort in Hong Kong, which is a result of a combination of availability of HCC tissues, technical platform, and data interpretation.
- Enriched the understanding of the tumor microenvironment of liver cancer.
- Identified the mechanistic rationale of combined treatment with immune checkpoint inhibitor anti-PD1 and anti-TIGIT and the resistance mechanisms.
- Uncovered the extracellular vesicles as promising therapeutic targets.
- Organized an international conference (Keystone Symposium "Cancer Stem Cells: Advances in Biology and Clinical Translation") and yearly Symposia (2017-2021) on "Liver Cancer Stemness".
- Published around 100 internationally renowned research papers, including in Molecular Cancer, Journal of Hepatology, Gut, Gastroenterology, Molecular Cell, Hepatology, and Nature Communications.

吳教授及其研究團隊：

- 鑑定出多個關鍵治療靶點和生物標誌物，有助發展肝癌精準治療方案。
- 結合肝癌細胞取樣、技術平台和數據分析等應用，在香港建立了第一個肝癌患者單細胞核糖核酸測序的群組研究。
- 豐富了對肝癌微環境的認識。
- 確定了結合免疫檢查點抗 -PD1 及抗 -TIGIT 和耐藥機制的治療機制原理。
- 揭示了以細胞外囊泡作為潛在的治療靶點。
- 舉辦了國際學術會議 (Keystone 學術會議 "癌症幹細胞：生物學與臨床轉化的發展") 及以 "肝癌幹性" 為主題的年度會議 (2017-2021)。
- 共於頂尖國際期刊發表了約 100 篇研究論文，包括 Molecular Cancer，Journal of Hepatology，Gut，Gastroenterology，Molecular Cell，Hepatology，and Nature Communications。

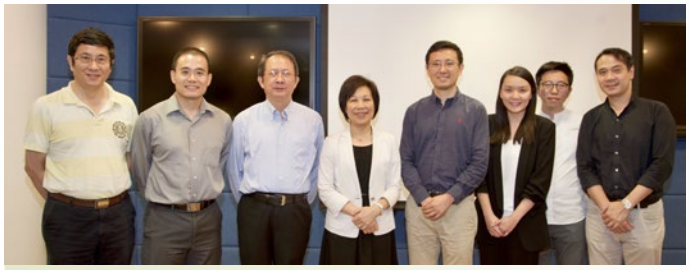


Photo of Speakers of 2018 Symposium, Professor Irene NG and project team
2018 會議講者與吳呂愛蓮教授及研究團隊成員合照

Photo of TRS project team members after 2020 Scientific Advisory Board visit (e-visit)
研究團隊成員於 2020 年科學顧問委員會線上視察後合照

Gastric Cancer Genomics and Beyond — Moving from Patient Samples to 3D Organoid Cultures for Integrative Genomics Analysis, Drug Sensitivity Assays, Cell Biological Studies and Animal Models

胃癌基因組學與發展：以病人活組織培養三維類器官細胞團作整合性基因組分析、藥物敏感測定、細胞生物學及動物模型研究

T12-710/16-R

Project Coordinator 項目統籌人

Professor Suet-yi LEUNG 梁雪兒教授
The University of Hong Kong 香港大學

Participating Institutions 參與院校

Hong Kong Baptist University 香港浸會大學
The Chinese University of Hong Kong 香港中文大學

Short Biography of Project Coordinator 項目統籌人簡介

Professor Suet-yi LEUNG is currently a Clinical Professor in the Department of Pathology, School of Clinical Medicine, Chair of Gastrointestinal Cancer Genetics and Genomics and Director of the Centre for PanorOmic Sciences (CPOS) at the LKS Faculty of Medicine, The University of Hong Kong. She is also Chief of Service in the Department of Pathology and Director of the Hereditary Gastrointestinal Cancer Genetic Diagnosis Laboratory at Queen Mary Hospital. Her research is focussed on the molecular genetics and genomics of gastric and colorectal cancers, and the application of molecular classification and genetic diagnosis of these malignancies to facilitate genome-guided patient stratification, prognostication and personalised treatment.

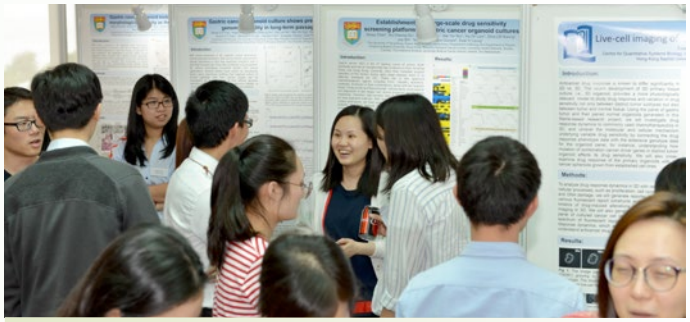
梁雪兒教授現任香港大學李嘉誠醫學院病理學系臨床教授、腸胃癌基因組學講座教授及泛組學科研中心總監。她亦擔任瑪麗醫院病理部和遺傳性胃腸癌基因診斷化驗室主管。她的研究重點是腸胃癌的分子遺傳學和基因組學，以及通過分子分類技術和基因診斷來幫助病人惡性腫瘤分型診斷、預後和個性化治療。

Project Summary 項目概要

- Generated stepwise combination cancer driver alterations in normal gastric organoids that could recapitulate different molecular subtypes in order to characterise the complex alternative pathways of gastric carcinogenesis and predict drug sensitivity.
- Generated a biobank of gastric cancer organoids that encompassed all known subtypes, as well as all known genomic alterations that have been reported.
- Performed large-scale drug screening using the organoid biobank for drug sensitivity testing and identification of new therapeutic opportunities.
- Studied survival mechanisms, signalling pathway deregulation, cancer stem cell phenotype and drug resistance mechanisms using live cell imaging, systems biology approaches, and functional genomic screens using CRISPR/Cas9 technology.
- Developed new methods for integrative genomic analysis to identify novel cancer driver pathways and predict new drug targets.

- 使用胃癌腫瘤類器官模型，生成具有遞進式多樣化癌症基因突變組合的胃癌腫瘤類器官，以模擬不同分子亞型的胃癌發生過程，從而解析其中複雜的分子通路以及預測藥物敏感性。
- 建立了一個胃癌類器官的生物庫，包括所有已知的胃癌亞型，以及所有已報道和已知的胃癌基因組突變。
- 利用類器官生物庫進行大規模的藥物篩選，通過高通量藥物敏感性測試去探索嶄新的胃癌治療方案。
- 使用活細胞成像、系統生物學和 CRISPR/Cas9 功能基因組篩選技術，研究胃癌細胞生存機制，信號通路調節，癌症腫瘤幹細胞表型和耐藥機制。
- 開發了綜合基因組分析的新方法，以確定新的癌症驅動途徑並預測新的藥物靶點。

Project Team leaders in discussion at a management committee meeting
項目各團隊負責人參與管理委員會討論



Poster session at a Project Team Research Retreat
項目報告會上的海報展示環節

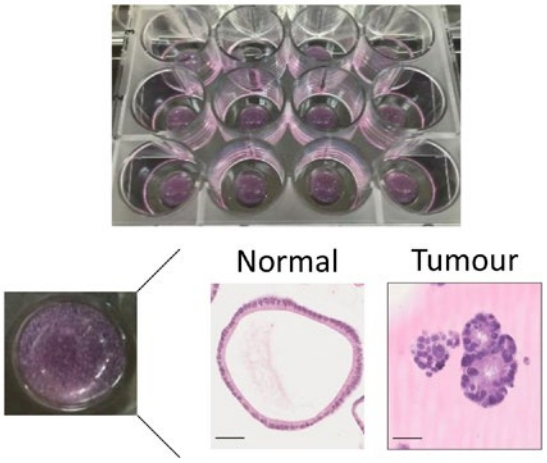
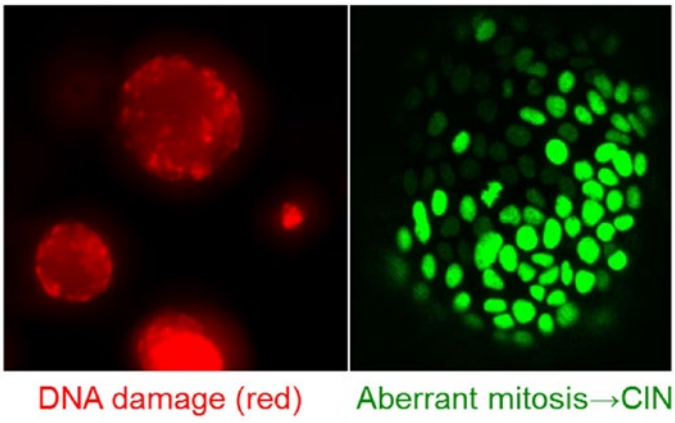


Image of Matrigel droplets in a tissue culture plate containing organoids, with representative H&E images of normal gastric and cancer organoids
類器官於基質膜內的培養照片，正常胃類器官與癌症腫瘤類器官的組織染色切片對照



Live imaging of mutant organoids, generated from normal organoids using Crispr/Cas9 technology, displaying abnormal mitosis
基因突變型類器官的實時成像，由 CRISPR/Cas9 技術對正常胃組織類器官進行基因編輯而培養得出，展示了異常有絲分裂過程

Abstract 項目簡介

Gastric cancer (GC) is the third leading cause of cancer death worldwide, with high incidence in China and Hong Kong and highlighting the urgent need for new treatment methods. GC is a heterogeneous disease involving different combinations of mutations in cancer driving genes. Therefore, a one-size-fits-all approach to treatment is often not effective. Previously, we built a tissue bank of hundreds of patients, with clinical and pathological data, long-term patient outcome data and genomic data, including whole-genome/exome sequencing, gene expression profiling and methylation profiling. In this project, we generated a biobank of 3D organoids to compliment our existing tissue bank. Genomic studies were performed on the organoids and found to match the data collected from matched patient tissue, thereby providing a platform for individualised patient drug testing. Therefore, we used these organoids for large-scale drug screening, allowing us to correlate drug sensitivity with specific genomic perturbations. Moreover, we used the organoids to perform deep mechanistic studies of gastric cancer pathways, stem cell properties and drug resistance mechanisms, developing new mouse models for in vivo drug testing and novel methods for integrative analysis along the way. Overall, our results showed that organoids offer a drug screening platform that could guide patient treatment and clinical trials to accelerate anti-cancer drug development.

胃癌是全球第三大癌症死亡原因，其在中國和香港的高發病率， 凸顯了對新治療方法的迫切需求。胃癌是一種多樣化疾病， 涉及各種癌症驅動基因的不同突變組合。因此，一刀切式治療方案往往會對胃癌無效。此前，我們建立了一個數百名患者的組織庫，其中包括臨床和病理數據、患者長期預後數據以及基因組數據，基因組數據包含全基因組 / 外顯子組測序、 基因表達譜和甲基化譜。在這個項目中，我們生成了一個三維類器官的胃癌生物樣本庫，也是對早前胃癌組織庫的補充。 項目亦對類器官進行基因組研究，發現腫瘤類器官與匹配的病人組織中檢測到的數據相吻合，從而證明了胃癌類器官可為精準醫療的藥物測試提供一個可靠的檢驗平台。因此，我們使用這些類器官有機體進行了大規模的藥物篩選，建立了藥物敏感性與特定的基因組變異之間的關聯性。此外，我們利用類器官進行胃癌發生途徑、幹細胞特性和抗藥性機製的深層機理研究，為體內藥物測試開發了新的小鼠模型，並在此過程中開發了綜合分析的新方法。 總括來說，我們的研究結果顯示，胃癌腫瘤類器官可提供一個可靠的藥物篩選平台，用來指導病人的治療和臨床試驗，並加速抗癌藥物的開發。

Research Impact 研究影響

Professor LEUNG and the team have produced a gastric cancer organoid biobank with linked genomic data and paired original tumours, that represents a landmark bioresource for the cancer research community worldwide. Using this biobank, we continue to generate drug sensitivity data from large-scale drug screening, with subsequent linkage back to patient genomic data. As a result, we are able to utilise genomic technology to identify novel pathways, biomarkers, drug targets and driver genes of carcinogenesis, facilitating the future development of precision cancer therapies, identifying new therapeutic opportunities targeting combination driver alterations and potentially widening the usage of existing drugs.

梁教授及其研究團隊建立了一個胃癌類器官生物庫，其中包含有類器官的基因組數據以及配對的原始腫瘤數據。對全世界的癌症研究界來說，這是一個地標性的重大生物資源庫。利用這個生物樣本庫，我們從大規模的藥物篩選中產生了大量針對特定病人基因組的藥物敏感性數據。最後，我們能夠利用基因組技術來尋找新的分子信號途徑、生物標誌物、藥物靶點和致癌的驅動基因，從而促進未來癌症精準療法的發展，發現針對基因突變組合的新治療方案，並擴大現有藥物的使用範圍。

Translational Studies for Elucidating the Tumor Heterogeneity and Molecular Evolution in Metastatic Gastrointestinal Tract Cancers for Personalized Medicine

闡明轉移性胃腸道癌細胞的異質性和分子進化過程以促進其個體化醫療的研究

T12-701/17-R

Project Coordinators 項目統籌人

Professor Maria Li LUNG 龍李梅瑞教授
(Nov 2017-June 2022 2017 年 11 月至 2022 年 6 月)

Professor Simon Ying-kit LAW 羅英傑教授
(July 2022-Oct 2022 2022 年 7 月至 10 月)

The University of Hong Kong 香港大學

Participating Institutions 參與院校

National University of Singapore 新加坡國立大學
Griffith University, Australia 澳洲格里菲斯大學

Surgery, Clinical Oncology, and Pathology team members
本專案外科學系、臨床腫瘤學系與病理學系團隊成員

Short Biography of Project Coordinator 項目統籌人簡介

Professor Maria Li LUNG, Chair Professor and Professor Emeritus of the Department of Clinical Oncology of The University of Hong Kong (HKU), graduated from Cornell University and received PhD at Stanford University. She did postdoc at Massachusetts Institute of Technology before joining HKU's Department of Microbiology. She was a founding member and Chair Professor of the Department of Biology at The Hong Kong University of Science and Technology (HKUST) and established HKUST Center for Cancer Research. In 2009, she returned to HKU's Department of Clinical Oncology. Professor LUNG is a leading researcher in cancer genomics, focusing on elucidating the molecular genetic basis of nasopharyngeal carcinoma (NPC) and esophageal carcinoma (ESC) and using functional, molecular and next-generation sequencing (NGS) approaches to identify key tumor suppressor genes and useful diagnostic cancer biomarkers. Her NGS studies led to understanding the molecular genetic basis and the molecular landscape of mutations in NPC and ESC. She has led several group RGC research grants. Her current project focuses on translational studies of tumor heterogeneity and molecular evolution in gastrointestinal (GIT) tumors.

龍李梅瑞教授現擔任香港大學臨床腫瘤學系講座教授及榮休教授。她於紐約康奈爾大學和加州史丹福大學分別獲得學士及博士學位。她在加入香港大學微生物學系前在麻省理工學院進行博士後研究。她亦是香港科技大學生物學系創始成員及講座教授並創立香港科技大學癌症研究中心。她於 2009 年重返香港大學就任臨床腫瘤學系講座教授。龍教授是癌症基因組學領域的領先研究者，致力於闡明鼻咽癌和食道癌的分子遺傳基礎，並通過各種功能性分析、分子分析及次世代定序科技識別出關鍵腫瘤抑制基因及用於癌症檢測的診斷生物標誌物，而且其所進行的次世代定序研究為理解鼻咽癌及食道癌中分子遺傳基礎和突變的分子情況鋪平了道路。她領導多個研資局資助的大型研究項目。本主題研究計劃項目主要針對消化道癌症腫瘤異質性和分子演化的相關轉化性的研究。

Professor Simon LAW, Cheung Kung-Hai Professor in Gastrointestinal Surgery, Chair Professor and Chief of Esophageal and Upper Gastrointestinal Surgery of HKU, graduated from the University of Cambridge and received surgical training at HKU. Professor LAW's clinical interests are on benign and malignant disorders of the upper GIT, motility disorders, gastro-esophageal reflux disease, and therapies such as endoscopic techniques, multimodal strategies, and surgical methods including minimally invasive and robot-assisted surgery. He has served as Council Member of The College of Surgeons of Hong Kong and Chairman of the General Surgery Board. Internationally he has held positions in various academic societies. He is currently President of the International Society of Diseases of the Esophagus, and an honorary member of both the American Surgical Association and European Surgical Associations.

羅英傑教授現擔任香港大學明德教授腸胃外科鍾江海基金教授，香港大學外科學系講座教授與外科學系食道及上消化道外科主任。他畢業於英國劍橋大學，並在香港大學外科學系接受外科培訓。羅教授專注上消化道良性和惡性疾病的臨床治療與研究、動力障礙和胃食道反流病，以及包括各種內窺鏡技術、多模式治療和微創機器人輔助手術在內的手術方法。他曾擔任香港外科醫學院理事會成員及普通外科委員會主席，亦在許多國際學術組織中擔任重要職位。他現任國際食道疾病協會主席，並為美國外科協會及歐洲外科協會之榮譽會員。

Clinical Oncology and Psychiatry team members
來自臨床腫瘤學系與精神醫學系的研究團隊成員

Project team and international advisors
研究團隊與國際顧問

Project Summary 項目概要

The aim of this project is to examine important parameters for risk stratification and improved therapies of GIT cancers, decipher the molecular basis of ESC metastasis and tumor heterogeneity and translate findings to the clinic. Specifically we aim to:

- Decipher the molecular basis of ESC metastasis and tumor heterogeneity.
- Identify predictive biomarkers for chemoresistance.
- Improve treatment outcomes for GIT cancer patients by non-invasive real-time monitoring for early relapse.
- Establish patient-derived metastatic circulating tumor cell (CTC) models for drug testing & functional studies.

本項目旨在檢驗可改進消化道癌症療效之患者風險分層的重要參數，重點分析食道鱗狀細胞癌轉移及腫瘤異質性的分子基礎、並將其發現轉化為臨床應用。具體而言，我們的目標是：

- 解讀食道鱗狀細胞癌轉移和腫瘤異質性的分子基礎。
- 識別化療抗性的預測性生物標誌物。
- 通過無創性實時監測技術識別早期復發，以改善消化道癌症患者的治療結果。
- 為藥物測試和功能性研究建立新的患者衍生轉移性循環腫瘤細胞模型。

Abstract 項目簡介

Esophageal cancers are deadly cancers due to late diagnosis. We aimed to identify and characterize molecular alterations and mutations associated with tumor metastasis to understand disease mechanisms and identify useful markers to improve diagnosis. CTCs from primary and metastatic tumors are shed into the blood stream and allow non-invasive real-time detection of cancers. We aimed to determine the usefulness of CTCs to understand tumor heterogeneity, identify useful markers hallmarking metastasis, patient stratification, and actionable targets for improved treatment, and to identify important immune and stromal contributors to cancer.

Retrospective and serial analysis of ESC patients undergoing treatment was performed to identify predictive markers associated with treatment outcomes. We aimed to identify genetic alterations in metastatic tumors of known good/poor chemoradiotherapy (CRT) responders from archived ESC patient tissues, as predictive biomarkers for patient stratification and improved guidance of treatment options. We determined the clinical utility of liquid biopsies for non-invasive real-time monitoring for metastasis and drug resistance for GIT cancers to expand treatment choices for precision medicine. We established a bank of organoid tissues directly from tumor tissues to establish animal models to evaluate drug efficacy.

食道癌通常於晚期才得到診斷，使其死亡率高居不下。我們旨在識別與腫瘤轉移直接相關的基因組改變和關鍵突變，進一步認識疾病機理，並鑒定出有用的標誌物以改善疾病診斷。循環腫瘤細胞隨著腫瘤發展及轉移而進入血液循環， 這使得我們可藉此對癌症進行無創性實時監測。我們旨在鑒定該類循環腫瘤細胞，以闡明其在研究腫瘤異質性及辨認出與癌症轉移、病人分層，以及改善治療的可行目標相關之標誌物中的可用性，並識別出對癌症發展起重要作用的免疫及基質因素。

我們對接受治療的食道鱗狀細胞癌患者進行回顧性系列分析，以確定與治療結果相關的預測標誌物。我們旨在從患者的存檔組織中識別已知對放化療反應良好或反應不佳的患者其轉移性腫瘤中存在的基因改變，以作為患者分層預測生物標誌物，及對治療改進選擇進行指導。我們進一步對液體活檢進行研究，旨在確定其於無創性實時監測胃腸道癌症分子進化和耐藥性轉移方面的臨床效用，以擴大精準醫療的治療選擇。此外， 我們利用患者活性腫瘤組織建立了類器官組織庫， 並已於裸鼠體內建立異種移植物以用於評估藥物療效。

Research Impact 研究影響

- Identification of useful biomarkers for patient prognostication using serial blood testing at different timepoints of patient treatment by ctDNA and CTC analysis and from whole genome sequencing of primary and nodal metastatic tumors to identify potential biomarkers for high-risk ESC patients with expected poor treatment outcomes.
- Establishment of a bank of organoids and patient-derived xenografts for evaluation of useful drugs and development of animal models.
- Assessment of dual cancers spatial inter- or intra-tumor heterogeneity. NGS data provided important implications for prognostication. Findings support multicentric independent clonal evolution and the theory of field cancerization, implicating an etiologic role of alcohol metabolism in dual ESC/hypo pharyngeal carcinoma (HPC) carcinogenesis.
- scRNA Seq elucidated the complex immunosuppressive interactions of various stromal cell types and the epithelial tumors in the ESC tumor microenvironment and identified potential prognostic cancer cell transcriptomic signatures.
- Whole-exome sequencing (WGS) data analysis allowed the discovery of the importance of genomic instability and in nodal metastases in ESC, as potential biomarkers to identify the high-risk esophageal squamous cell carcinoma (ESCC) patients with early death post-treatment.
- Analysis of the good and poor responders by comprehensive genomic profiling of Formalin-Fixed Paraffin-Embedded (FFPE) tissues from patients receiving neoadjuvant CRT identified potential biomarkers associated with relapse and death.

- 通過於患者治療的不同時間點進行系列血液檢測，對其中循環腫瘤去氧核糖核酸和循環腫瘤細胞進行分析，以識別對患者預後有用的生物標誌物；對原發性和淋巴結轉移性腫瘤進行全基因組測序，以識別治療結果不佳的食道鱗狀細胞癌高危患者之潛在生物標誌物。
- 建立來自患者組織的類器官庫及異種移植物，用於評估有用的藥物和開發動物模型。
- 評估雙重癌症之空間性的腫瘤間或腫瘤內異質性。次世代基因定序數據對預測患者預後具有重要意義。總體而言，我們的研究結果支持多中心獨立克隆進化和場癌化理論，並間接表明酒精代謝在雙重食道鱗狀細胞癌 / 肝癌致癌作用中的病因學作用。
- 單細胞核糖核酸定序的應用闡明了食道鱗狀細胞癌之腫瘤微環境中各種基質細胞類型和上皮腫瘤之間複雜的免疫抑制相互作用，並識別出可用於預後的潛在癌細胞轉錄組特徵。
- 全基因組定序數據分析發現基因組之不穩定性和染色體外去氧核糖核酸於食道鱗狀細胞癌淋巴結轉移中的重要性，並可作為潛在的生物標誌物來識別治療後較快死亡的高危患者。
- 通過對接受前導性放化療的患者其福馬林包埋組織進行綜合基因組分析及對良好或不良反應者資料的比較識別出與復發和死亡相關的潛在生物標誌物。

Functional Bone Regeneration in Challenging Bone Disorders and Defects
難愈骨疾病和骨缺損的功能性再生研究

T13-402/17-N

Project Coordinator 項目統籌人
Professor Ling QIN 秦嶺教授
The Chinese University of Hong Kong 香港中文大學

Participating Institutions 參與院校
City University of Hong Kong 香港城市大學
The University of Hong Kong 香港大學
The Hong Kong Polytechnic University 香港理工大學

Professor QIN and his research team
秦嶺教授及其研究團隊

Short Biography of Project Coordinator 項目統籌人簡介

Professor Ling QIN is Choh-Ming Li Professor of Orthopaedics and Traumatology, The Chinese University of Hong Kong (CUHK). Professor QIN has been working on basic and translational research in orthopaedics over the past 30 years. He published 9 books and over 360 SCI journal papers with an H-index of 66 and holds over 30 inventions or new utility patents from the Mainland China and the United States. Professor QIN received many prestigious honors and awards, including Fellow of American Institute for Medical and Biological Engineering (AIMBE), International Combined Orthopaedic Research Societies (ICORS), American Society for Bone and Mineral Research (ASBMR), and International Union of Societies for Biomaterials Science and Engineering (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 are highlighted in Nature and Science.

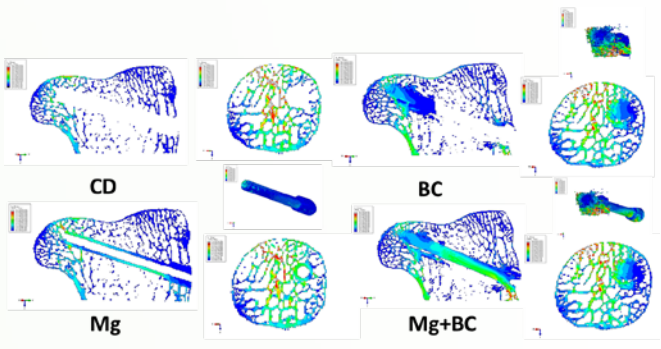
秦嶺教授現任香港中文大學卓敏矯形外科與創傷學教授。三十多年來，秦嶺教授從事骨科基礎和臨床醫學應用研究，主編 9 本專著和發表 360 篇 SCI 學術論文，H 指數 66；先後獲得 30 多項國際 / 地區性科研獎項和 30 多項中國內地及美國發明或實用新型專利。秦嶺教授個人也獲得多項殊榮，由於其在骨科研究和生物材料的創新研發貢獻突出，先後入選美國醫學與生物工程院、國際骨研聯合、美國骨礦鹽學會和國際生物材料科學與工程學會聯合會 Fellow。《自然》和《科學》期刊特別報導了秦嶺教授和團隊的三類醫療器械可降解金屬骨科內植物的創新研發和臨床轉化工作。

Project Summary 項目概要

- To develop and test bioactive, implantable or injectable, bioengineered products for orthopaedic diseases, including bone defect, anterior cruciate ligament reconstruction, and osteonecrosis of the femoral head.
- The design is based on clinical indications through an effective combination of secretome from bone marrow stem cells (BMSCs), innovative porous scaffolds, and injectable biomaterials incorporated with exogenous growth factors, metallic sutures for anterior cruciate ligament (ACL) reconstruction, and mechanical stimulation to facilitate the regeneration of challenging musculoskeletal conditions with impaired osteogenic potential of BMSCs.
- For enhancing bone regeneration, our innovative therapy would provide a favourable local microenvironment to maximize bone regeneration and remodelling.
- Understanding the underlying cell-material matrix- biophysical signal interaction and mechanisms during skeletal defect repair would be important to optimize the intervention protocols and maximize the therapeutic effects.

- 開發和測試具有生物活性的可植入或可注射的生物工程產品，用於骨科疾病，包括骨缺損、前交叉韌帶重建和股骨頭壞死等適應症。
- 該設計基於臨床適應症，通過有效結合來自骨髓間充質幹細胞（BMSCs）的分泌蛋白質組、創新的多孔支架，以及含有外源性生長因數的可注射生物材料等，研發用於 ACL 重建的金屬縫合線，以及通過機械刺激等促進難愈型肌肉骨骼疾病的組織再生和其中活性受損的 BMSCs 的成骨潛力。
- 為了促進骨再生，我們的創新療法將提供一個適宜的局部微環境，以最大限度地促進骨再生和骨重塑。
- 理解骨骼缺損修復過程中的細胞與材料之間以及基質間的生物實體信號相互作用和機制，這對於優化干預方案和提升治療效果至關重要。

Project coordinator Professor Ling QIN (2nd from right) is showing Ms. Carrie LAM (the then Chief Executive of Hong Kong SAR Government, 3rd from right), Professor Rocky TUAN (ViceChancellor of CUHK, 3rd from the left) and Professor Chunli BAI (President of the Chinese Academy of Sciences, 2nd from left) the innovative biodegradable Magnesium-based orthopaedicimplants (November 8, 2018).
項目主任秦嶺教授（右二）向林鄭月娥女士（時任香港特別行政區行政長官，右三）段崇智教授（香港中文大學校長，左三）和白春禮教授（中國科學院院長，左二）展示創新可生物降解鎂基骨科內植物（2018 年 11 月 8 日）。



Proof-of-concept study using bipedal emu model
兩足動物鴕鳥模型的概念驗證

Abstract 項目簡介

The world population is ageing. Ageing is associated with many musculoskeletal problems, including primary or secondary osteoporosis (OP), osteoarthritis (OA), and chronic tendon-bone insertion disorder or injury, which often lead to bone fractures, joint deformity and disability. Our current research focuses on these skeletal disorders and injuries with limited repair and healing potential, including osteoporotic fracture, avascular osteonecrosis (AVN) around joints with extremely high incidence of OA, and tendon-bone insertion reconstruction. A significant reduction in quantity and quality of stem cells, especially bone marrow stem cells (BMSCs), are the most common features in these disorders. Substantial costs are involved in surgeries and subsequent rehabilitations for these severe musculoskeletal conditions and injuries that imposes huge socioeconomic and healthcare burden to the patient, family, healthcare system, and society in Hong Kong and worldwide. Therefore, our collaborative and multidisciplinary research focuses on enhancing treatment outcome of these skeletal disorders or injuries by augmenting the regenerative potential of autologous BMSCs and mobilizing circulating stem cells to bone defects for bone regeneration. To enhance osteogenesis, we will investigate the recruitment of circulating stem cells, mobilization of local BMSCs onto surface of the implanted biomaterials, and cell-matrix signalling with modulation of biophysical stimulation. To achieve our study objectives for targeting above mentioned musculoskeletal problems, this project is divided into three stages: 1) Osteogenic modulation of BMSCs for skeletal tissue engineering; 2) Investigation on the treatment efficacy of implanted innovative biomaterials and postoperative non-invasive biophysical modulation for maximizing the osteogenic efficacy using our well-established preclinical animal models; 3) Completion of the required biosafety testing for Class III medical implants for product registration and prepare for subsequent clinical trials. Our efforts will focus not only on high quality scientific research but also or more importantly, the research and development (R&D) of effective treatment protocols or strategies for achieving functional bone regeneration of challenging bone disorders. Ultimately, our innovative functional biomaterials and treatment protocols will benefit our patients with a significant reduction on healthcare burden both locally and internationally.

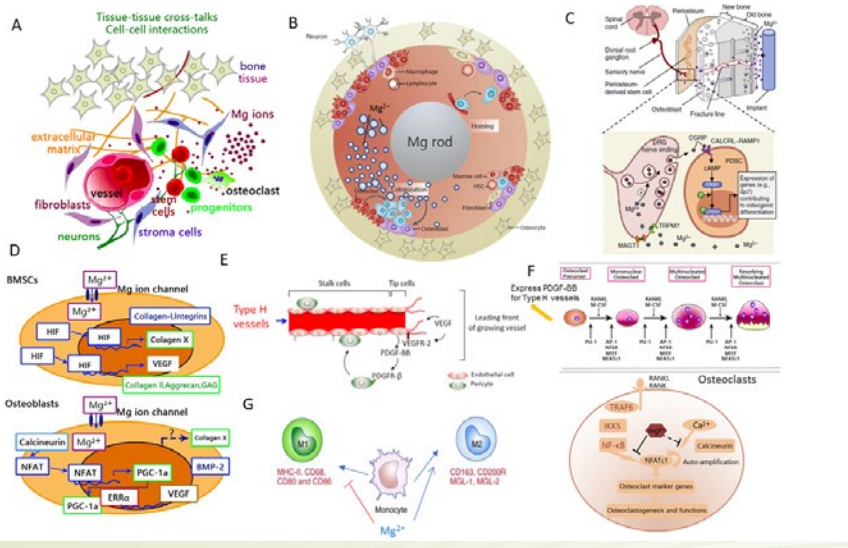
目前全球人口在急速老齡化。老齡化伴隨許多骨科疾病的發生，包括原發性或繼發性骨質疏鬆、骨性關節炎和慢性腱骨止點疾患或損傷，並經常導致骨折、關節變形和殘疾的發生。因此本項目研究將致力於對上述難治癒的骨科疾患和損傷治療策略的研發，包括骨質疏鬆型骨折、關節周圍缺血性骨壞死和極有可能導致的骨關節炎、腱骨結合部修復。我們發現罹患這些骨科疾病的患者通常具有如下特徵：即自身幹細胞尤其是骨髓間充質幹細胞（BMSCs）數量明顯不足且成骨分化能力嚴重下降。這往往導致手術及術後康復費用支出巨大，最終給患者本人及家庭、醫療衛生系統和香港及各地社會帶來巨大醫療挑戰和社會經濟壓力。本項目中，我們分別研究循環幹細胞的募集、局部組織中 BMSCs 在植入生物材料表面的遷移和在生物物理刺激下提升成骨細胞 - 基質信號通路，有效實現骨再生。為解決上述難治癒的骨疾患難題，本項目分三個階段進行：1）用於骨骼組織工程的 BMSCs 成骨分化調節；2）利用我們成熟的臨床前動物模型，研究植入創新型生物材料和術後非侵入式生物物理刺激手段的治療效果，提升成骨效果；3）對本項目中開發的醫療三類植入器械完成註冊所需的生物安全檢驗評估，以便後續的臨床測試。本項目不僅關注高質量的基礎研究，還致力於難治癒骨疾患治療手段的建立、開發和應用。期待我們研發的功能性生物材料和提出的治療策略能提升患者的療效，同時也大大減輕我們醫療保障系統的負擔。

Research Impact 研究影響

This project would provide evidence for accelerating the conversion of our innovation into clinical application. Our innovative orthopaedic implant would accelerate healing and regeneration and facilitation of early rehabilitee of patients. They may not need to face a second operation for removing the implants as our innovation is biodegradable metals, andeven it is required in some rare conditions, then less surgical intervention is needed so this will avoid psychological suffers from the patients and also the financial burdens involved. Furthermore, there are new initiatives for regulatory bodies to establish new standards and new testing protocols to enrich current International Standard Organization (ISO) standardsfor medical implants or devices. This project is a revolution in our clinical practice using Mg-based biodegradable metals that facilitate early musculoskeletal regeneration, avoid implant removal surgery, promise early rehabilitation, relieve the burden of our healthcare system and finally generate huge socio-economical impact.

本項目將提供科學證據促進我們的創新成果轉化為臨床應用。我們的創新型骨科內植物將加速治療、組織再生和促進患者康復。因為我們的創新型內植物是基於可生物降解的金屬，除特殊情況外，患者可避免進行二次手術來移除內植物，這不但可以避免病人的心理壓力，也減少了相應的醫療負擔。此外，我們將協助監管機構建立新標準和新測試指南，以完善國際標準組織（ISO）的三類醫療植入物或相關設備的檢測標準。此項目是我們在臨床實踐中的一項革新，使用基於鎂的生物可降解金屬，可有效促進骨骼再生，避免骨科內植物的二次移除手術，加速康復，減少我們醫療體系的負擔，最終可體現顯著的社會經濟效益。

Design of innovative Mg-based hollow stent to be inserted into proximal femur after core decompression to facilitate the delivery of injection of bioactive materials
創新型鎂基空心棒設計，在髓內減壓後插入股骨近端，以方便生物活性材料的注入



Molecular and cellular mechanism of osteogenesis attributed to degradation by-products of Mg-based implants and injectable biomaterials
鎂基內植物和可注射生物材料的降解副產物促進成骨的分子和細胞機制

Diagnosis and Prognosis of Intensifying Eutrophication, Hypoxia and the Ecosystem Consequences around Hong Kong Waters: Coupled Physical-biogeochemical-pollution Studies

香港及鄰近海域富營養化，缺氧及生態後果的診斷和預測：物理 - 生物地球化學 - 污染耦合研究

T21-602/16-R

Project Coordinator 項目統籌人

Professor Jianping GAN 甘劍平教授

The Hong Kong University of Science and Technology 香港科技大學

Participating Institutions 參與院校

The University of Hong Kong 香港大學
City University of Hong Kong 香港城市大學
The Hong Kong Polytechnic University 香港理工大學
The Chinese University of Hong Kong 香港中文大學
Xiamen University 廈門大學
Institute of Atmospheric Physics, Chinese Academy of Sciences 中國科學院大氣物理研究所

Short Biography of Project Coordinator 項目統籌人簡介

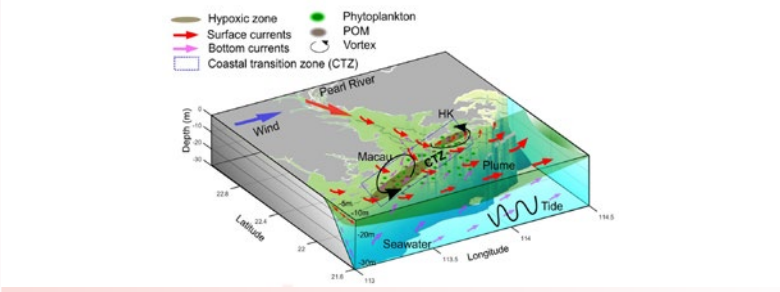
Professor Jianping GAN is a Chair Professor in the Department of Ocean Science, Department of Mathematics and Division of Environment and Sustainability at The Hong Kong University of Science and Technology. He is a leading physical oceanographer and has made substantial contributions to the geophysical fluid dynamics of ocean circulation and interdisciplinary numerical ocean modeling studies. He has published over 100 papers in leading international journals and led several large-scale research projects in the United States, the Mainland China, and Hong Kong. Professor GAN is well known in the field and was elected as the founding President of the Ocean Section and council member of the Asia Oceania Geosciences Society.

甘劍平教授是香港科技大學海洋科學系、數學系和環境及可持續發展學部講座教授，是業內著名的海洋物理學家。甘教授在海洋環流地球物理流體動力學和跨學科海洋數值模擬等方面作出開創性的研究，在國際頂級海洋學期刊發表了 100 多篇學術論文。甘教授在美國、中國內地和香港領導多項大型研究項目。他被選為亞洲大洋洲地球科學學會的理事會成員和海洋科創始主席。

Project Summary 項目概要

- For the first time, seasonal eutrophication-driven bottom hypoxia of total area greater than 660-780 km^2 in coastal waters off Hong Kong (HK) was identified to be persistent along the coastal transition zone (CTZ) between the Pearl River Estuary and the adjacent continental shelf and attributed to joint biogeochemical and hydrodynamics conditions locally.
- The eutrophication-derived organic matter (OM) accounted for ~65% of total oxygen consumption in the bottom hypoxic waters, while terrestrial OM directly contributed ~25% and indirectly promoted hypoxia development by releasing nutrients.
- The bottom hypoxia reduced the acid-base buffering capacity of seawater and seriously aggravated the coastal acidification.
- The hypoxia in the CTZ exhibited remarkable spatiotemporal variability due to changes of the path of the nutrient-rich river plume, strength of mixing, and length of water residence time by variable coastal current. Hypoxia in Victoria Harbour was jointly controlled by external influx and internal hydrodynamics and biogeochemical processes.

- 首次發現香港近海季節性、持續富營養化和海底缺氧（總面積大於 660-780 平方公里）發生於珠江口沿海過渡帶（CTZ）。缺氧形成是由於該過渡帶受珠江河口和鄰近陸架海獨特的渦流水動力和生物地球化學過程共同控制，二者缺一不可。
- 導致缺氧的有機質近約 65% 來自於海源富營養化。河流陸源有機質不但對缺氧有約 25% 的直接貢獻，而且同時通過營養鹽增加間接貢獻水體低氧的形成。
- 海底缺氧降低海水酸鹼緩衝能力，並加劇了海岸帶水體酸化。
- 持續的季節性富營養化和缺氧在珠江口沿岸過渡帶表現出顯著的時空變化。此變化由風向變化改變含高營養鹽淡水羽狀流的路徑、水體混合強度和滯留時間來調節和影響缺氧區的時空變化。香港維多利亞港的水體缺氧直接受外部的鄰近沿海水輸入的影響，且同時間接受港內局地水動力和生物地球化學過程調控。



Location of hypoxia and its formation mechanism off HK and the Greater Bay Area
大灣區及香港缺氧海區的形成機制

Professor Jianping GAN on field survey cruise
甘劍平教授進行海上調查

- Microbes and nitrification played a significant role in the bottom hypoxia near HK. P-limitation can reverse its impact from reducing to expanding coastal hypoxia via the interacting limitation-induced changes in surface production and bottom oxygen influx.
- The shoreward transport of OM from the subsurface chlorophyll maximum (SCM) offshore played a critical role in triggering hypoxia formation when river discharge was low.
- The oceanic hypoxic area off HK and the Greater Bay Area (GBA) is predicted to double in the next 30 years. Oyster farming is scientifically proven to be a promising approach to mitigate eutrophication and hypoxia.

- 微生物和硝化作用對鄰近香港水域底部缺氧中心形成發揮著重要作用。河口近海顯著的磷限制對缺氧的影響可從縮減氧範圍逆轉成擴大缺氧範圍，該逆轉受控於磷限制導致的表層浮游植物分佈變化及與之關聯的底層向岸輸送的氧氣通量。
- 當河流排放量和陸源營養鹽輸入較低時，近海深水中的葉綠素最大層（SCM）中的有機質向岸輸送亦可引發缺氧區的形成。
- 在未來 30 年，我們預測香港和大灣區海域的缺氧面積將增加一倍。科學研究發現，牡蠣養殖是緩解水體富營養化和缺氧的極具前景的方法之一。

Abstract 項目簡介

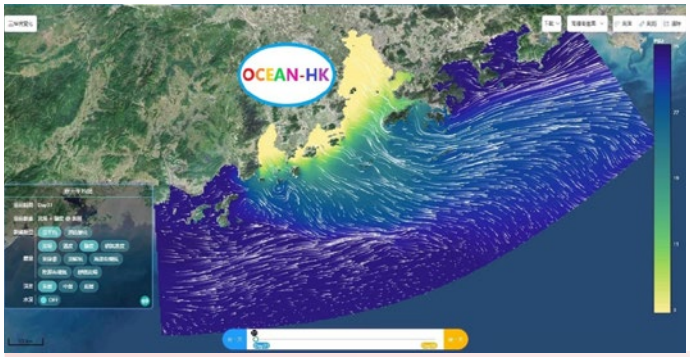
Eutrophication/hypoxia (oxygen concentration<2 mg/L) in the bottom has been a hazard to the ecosystem and our living environment in Hong Kong and other coastal waters for decades. The oceanic waters in Hong Kong and the Greater Bay Area are affected by persistent and increasing eutrophication/hypoxia, which could offset the environmental improvements achieved through the costly Harbour Area Treatment Scheme (HATS) over the last 10 years. This OCEAN_HK project (https://ocean.ust.hk/), for the first time, holistically provides scientific evidence to explain how, where, and when this marine hazard occurs, predicts its long-term trend, and offers novel mitigation and management schemes to tackle this serious marine environmental challenge we are facing.

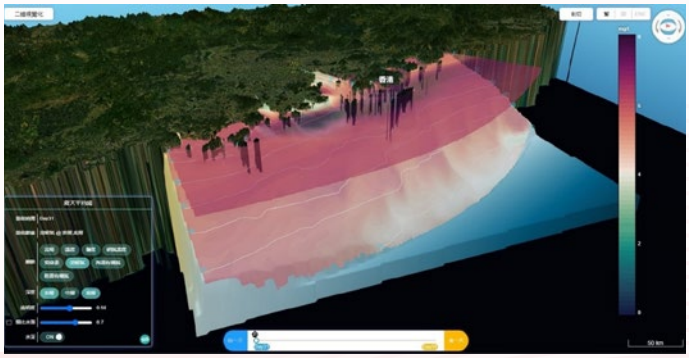
沿海富營養化和海底缺氧（溶解氧濃度 <2 mg/L）對全球海洋生態系統和人類生活環境有巨大的危害。香港沿岸水域也受到持續和日益嚴重的富營養化和缺氧影響，從而可能抵消過去十年通過昂貴的海港區域治理計劃（HATS）擬實現的海洋環境改善。本海洋主題研究計劃（OCEAN_HK，https://ocean.ust.hk/）首次基於科學證據，對香港和大灣區水域富營養化和海底缺氧產生的機理、地點、時間和長期變化趨勢提供了全方位的科學解析，為困擾香港乃至全球沿海的缺氧問題提供了創新的管理和調控科學方案。

Research Impact 研究影響

- OCEAN_HK unveiled the formation mechanism of hypoxia, developed oceanographic research capability, and provided much needed information to stakeholders and governments.
- The project has launched the first Online Marine Environmental Visualization Platform in the region (WavyOcean, https://ocean.ust.hk:8443/SiteMapApi/new/index.jsp), which offers a "one-stop shop" for sharing scientific knowledge and data that can help policymakers strike a balance between marine conservation and social development (e.g. the Lantau Tomorrow Vision project). WavyOcean records about 100 visits and data downloads a day, and the mobile app has been downloaded >3000 times. Both OCEAN_HK and WavyOcean have attracted great attention from mainstream media and the broader community in Hong Kong and the Mainland China.
- The scientific output from the OCEAN-HK project is being considered as a case study in a Special Policy Study on Global Ocean Governance and Ecological Civilization (2017–2019) sponsored by China Council for International Cooperation on Environment and Development.
- OCEAN-HK is an integral part of COASTAL-SOS which is a project endorsed by the United Nations Decade of Ocean Science for Sustainable Development (2021-2030).

- OCEAN_HK 首次揭示了香港和大灣區海域缺氧形成的綜合機制，提高了香港對海洋管理和研究的整體能力，也惠及了政府和其他持份者。
- 該項目開發了首個在線海洋環境可視化平台 (WavyOcean https://ocean.ust.hk:8443/SiteMapApi/new/index.jsp)，為提供科學知識及數據以及海洋保育和社會發展的平衡計劃（如明日大嶼遠景計劃）提供一站式服務功能。目前，WavyOcean 手機應用程式有超過三千次下載，平台日均收到過百次的訪問和資料下載。OCEAN_HK 和 WavyOcean 受到了香港和中國內地媒體、學術界和非學術界的廣泛關注。
- OCEAN-HK 的科學成果被中國環境與發展國際合作委員會（國合會）主辦的《全球海洋治理與生態文明專項政策研究 (SPS) (2017-2019) 》考慮列作案例研究。
- OCEAN_HK 被列入聯合國海洋科學促進可持續發展的十年計劃（2021-2030）（聯合國十年 UN-Decade）的 COASTAL-SOS 項目。





WavyOcean Online Visualization Platform
WavyOcean 在線可視化平台

Enhanced Separation and Sludge Refinery for Wastewater Treatment – Solving the Nexus of Pollution Control and Resource Recovery in Mega Cities

高效濃縮分離和污泥精煉協同新技術實現城市水污染控制和資源回收

T21-711/16-R

Project Coordinator 項目統籌人
Professor Xiao-yan LI 李曉岩教授
The University of Hong Kong 香港大學

Participating Institutions 參與院校
The Hong Kong Polytechnic University 香港理工大學
The Hong Kong University of Science and Technology 香港科技大學
City University of Hong Kong 香港城市大學

Annual meeting of the project team with one of International Advisors of the TRS project, Professor James LECKIE from Stanford University (May 10, 2019 at HKU)
項目成員與項目顧問斯坦福大學 James LECKIE 教授進行年度工作會議。(2019 年 5 月 10 日於香港大學)

Short Biography of Project Coordinator 項目統籌人簡介

Professor Xiao-yan LI is a Chair Professor in Department of Civil Engineering, The University of Hong Kong (HKU). He has over 30 years of research experience in advanced water and wastewater treatment and resource recovery. He received First-Class Outstanding Research Achievement Award in 2012 from Ministry of Education, Second-Class State Natural Science Award in 2014 from State Council, and Second-Class Award in Environmental Technology in 2019 from Ministry of Ecology and Environment, China. Professor LI has been an ESI top 1% highly cited author since 2009, and he has obtained over 15 patents with the licensing of two patents for IP transfer and commercialization.

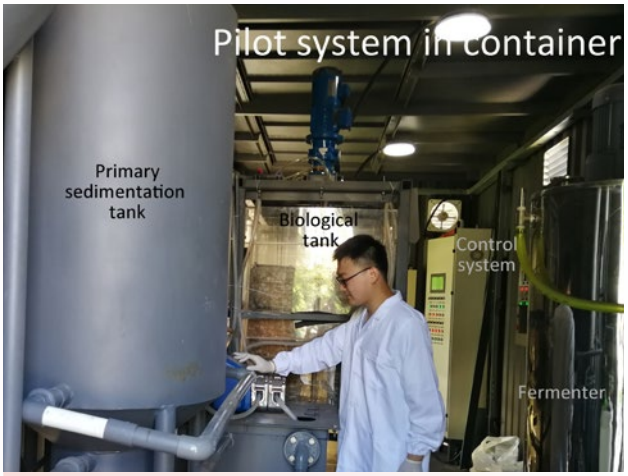
李曉岩教授是香港大學土木工程系講座教授，在水和污水深度處理及資源回收方面有 30 多年的研究經驗。李教授於 2012 年獲中國教育部優秀研究成果一等獎，2014 年獲國家自然科學二等獎，2019 年獲生態環境部環保技術二等獎。自 2009 年以來，李教授一直是 ESI 前 1% 的最高被引用作者，並獲授權專利超過 15 項，其中兩項專利已實現技術轉化。

Project Summary 項目概要

- Development of an innovative chemical-biological wastewater treatment process for high nutrient removal, small footprint, energy-saving, and phosphorus and organic recovery;
- Development of a novel sludge treatment system that can greatly reduce the waste sludge and recover energy and resources for valuable products;
- Pilot trials and demonstration of the novel wastewater treatment scheme, and assessment of the system performance and environmental impacts of the effluent.

- 開發一套新型的具有污染物高效去除和低碳節能特點的化學 - 生物污水處理技術，並實現污水中有機物和磷資源的有效回收；
- 開發新的污泥處理方式，大幅降低剩餘污泥排放，並同步實現資源和能源的回收；
- 開展新型污水處理系統的中試集成和示範運行，評估其綜合效果及其出水水質的環境影響。

Workshop of the TRS project for research postgraduate students and post-doctoral fellows (June 26, 2021 at HKU and online)
項目的研究生及博士後學術研討會（2021 年 6 月 26 日於香港大學及線上）



Pilot plant of the advanced wastewater treatment system inside a container tank at Nanshan Wastewater Treatment Plant in Shenzhen, China
測試深圳市南山污水處理廠的集成式污水處理系統

Abstract 項目簡介

Most core wastewater treatment technologies were developed more than half a century ago and thus they are no longer capable of accommodating the fast population growth, industrialization and urbanization. Removal of pollutants in wastewater treatment is not only difficult and costly, but also produces a large amount of sludge. Disposal of sewage sludge is one of the most challenging and expensive environmental problems for large cities. On the other hand, major pollutants (organics and nutrients) in wastewater are valuable resources that should be recovered instead of being degraded or wasted with the sludge.

In this project, novel technologies, namely Enhanced Separation and Sludge Refinery (ESSR), has been developed for advanced wastewater treatment, together with effective resource recovery. The theme-based research includes three programmes: (a) Chemicallyenhanced Membrane Filtration (CeMF) and side-stream Acidogenic sludge and food waste CoFermentation (sACF) for Phosphorus and organic capture and recovery; (b) treatment of the waste sludge by thermal Sludge Hydrolysis followed by fungal Fermentation and Refinery (SHFR) for waste minimization and resource recovery; and (c) integration of the novel ESSR modules for advanced wastewater treatment. The technological development achieved in this project will fundamentally transform wastewater treatment from an end-of-the-pipe purification process to a resource-mining practice for value-added products including fertilizers, organic acids, ethanol and bio-fibers. Towards the end, the innovative system will set an example with its both environmental and economic benefits for sustainable water pollution control in mega cities.

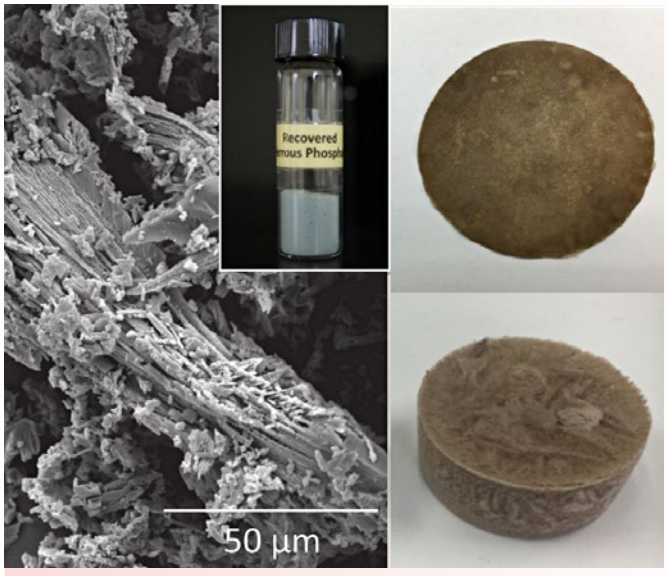
常規的污水處理技術已應用超過半個世紀，目前已無法適應快速增長的城市人口和工業化進程。污水處理過程緩慢且成本較高，並會產生大量的污泥。因此，污泥的處置是大型城市面臨的最具挑戰及昂貴的環境問題之一。然而，污水中的主要污染物（有機物和營養物）也是有價值的資源物質，應該加以回收利用而非被降解或與污泥一起排放棄置。

本項目開發了一套新型全面的污水處理工藝系統，即高效濃縮分離和污泥精煉協同的新技術（ESSR），實現資源的有效回收。此主題研究包括三個部分：(a) 採用化學強化陶瓷膜過濾（CeMF）和污泥 - 廚餘垃圾共發酵（sACF）捕獲和回收磷和有機物；(b) 通過污泥的熱水解及真菌發酵（SHFR）實現污泥減量和資源回收；(c) 開展工藝集成和 ESSR 污水處理系統中試。該創新技術將從根本上把污水處理從末端淨化轉變為資源回收和利用，將污染物轉化為化肥、有機酸、乙醇和生物纖維等增值產品，其研發和示範將為大型城市的可持續水污染控制提供優秀範例，具有廣泛環境和經濟效益。

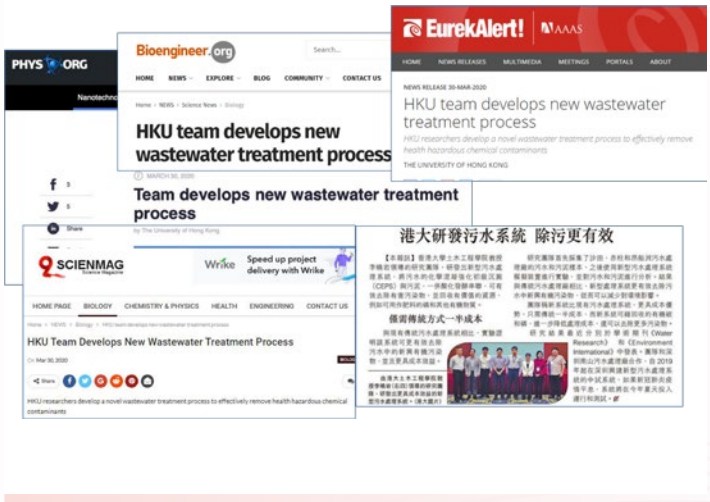
Research Impact 研究影響

The novel wastewater treatment system developed in this project can effectively remove pollutants and recover valuable resources such as phosphorus and organics. In the long term, the novel wastewater treatment system will contribute to the advancement of waste-to-resource technologies and can be applied in Hong Kong and elsewhere to update existing wastewater treatment facilities. Due to such significance, the TRS project team was invited to publish a thematic issue in HKIE Transactions, "Theme Issue on Sustainable Wastewater Technologies for Pollution Control and Resource Recovery" (June 2019, https://doi.org/10.33430/V26N2). Moreover, in March 2020, HKU publicized research findings of the project via a press release, and a number of local newspapers and international digital media reported our impactful research work. Besides, two patents of innovative filtration materials developed by the project team have been licensed to the industry for IP transfer and commercialization.

本項目所開發的新型污水處理系統可高效去除污染物並實現有機物和磷資源的回收，該技術可應用於香港及其他地區污水處理設施的升級改造，並推動污水污泥資源化。鑒於其重要性，項目團隊受邀在 HKIE Transactions 出版"可持續水污染控制技術和資源回收"的主題特刊（2019 年 6 月，https://doi.org/10.33430/V26N2）。香港大學亦於 2020 年 3 月發布新聞稿介紹本項目的研究成果，獲得了多家有影響力的本地媒體和境外科技網站的廣泛報道。此外，本項目研發的兩項新型過濾材料的專利成果已完成商業化應用的技術轉讓。



Phosphorus fertilizer (vivianite) recovered from wastewater (left), and waste sludge-derived paper sheet and packing pad made of fungus hyphae via thermal hydrolysis of the sludge followed by fungal fermentation (right)
從污水中回收的磷肥（藍鐵礦）(左)；污泥熱水解和真菌發酵後製成的菌絲紙片和海綿墊（右）



Media reports of the project activities and achievement
媒體報導有關項目研究的成果

Creation of Rechargeable Electron-fuels for Stationary Power Supplies and Electric Vehicles

用於可再生能源供電站及電動汽車的電燃料儲能技術基礎研究

T23-601/17-R

Project Coordinators 項目統籌人

Professor Tianshou ZHAO 趙天壽教授
(Jan 2018-Dec 2021 2018 年 1 月至 2021 年 12 月)
Professor Minhua SHAO 邵敏華教授
(Jan 2022-Dec 2023 2022 年 1 月至 2023 年 12 月)
The Hong Kong University of Science and Technology 香港科技大學

Participating Institutions 參與院校

The University of Hong Kong 香港大學
The Chinese University of Hong Kong 香港中文大學
The Hong Kong Polytechnic University 香港理工大學

Short Biography of Project Coordinator 項目統籌人簡介

Professor Tianshou ZHAO is a Chair Professor in the Department of Mechanical and Aerospace Engineering at HKUST, the founding Director of the HKUST Energy Institute, and a Senior Fellow of the HKUST Institute for Advanced Study. Professor ZHAO is an elected Academician of the Chinese Academy of Sciences, Fellow of the Chinese Society of Chemistry, Fellow of American Society Mechanical Engineers , and Fellow of the Royal Society of Chemistry. Professor ZHAO has been awarded the Croucher Senior Fellowship award, the Ho Leung Ho Lee Prize for Scientific and Technological Advancement, two State Natural Science Awards (Second Class Prize), and the Distinguished Research Excellence Award (HKUST). He is a Highly Cited Researcher and a World's Most Influential Scientific Minds named by Thomson Reuters and Clarivate. Prof ZHAO serves as Editor-in-Chief of *International Journal of Heat and Mass Transfer and a member of Advisory Board for Energy & Environmental Science*. His research has focused on the theory, technology, and applications of energy storage in renewable energy systems for more than 30 years. Using an interdisciplinary approach that combines thermo-fluid sciences with electrochemistry, he has established the coupled theory of thermal mass transfer-electrochemical reaction in fluid batteries. He has disclosed the ground-breaking concept of storing energy with electrically rechargeable liquid e-fuels in this project, achieving systematic innovations in energy storage.

Professor Minhua SHAO has taken the role of project coordinator since January 2022. Former project coordinator Professor Tianshou ZHAO stays in project team and continues contributing to the project.

Professor Minhua SHAO is currently the Cheong Ying Chan Professor of Energy Engineering and Environment, Chair Professor in the Department of Chemical and Biological Engineering at the Hong Kong University of Science and Technology (HKUST), and the Director of the HKUST Energy Institute. He earned his B.S. and M.S. degrees in chemistry from Xiamen University in China and his Ph.D. degree in materials science and engineering from the State University of New York at Stony Brook in 2006. Before joining the

趙天壽教授是香港科技大學機械及航空航天工程系講座教授、香港科大能源研究院創始院長及香港科大高等研究院資深學人。趙教授是中國科學院院士、中國化學學會會士、美國機械工程師學會會士及英國皇家化學學會會士。曾獲 Croucher 資深研究成就獎、何梁何利基金科學與技術進步獎、兩次獲得國家自然科學二等獎、香港科大工程學傑出研究成就獎、入選 Clarivate/Thomson Reuters 全球高被引科學家和最有影響力科學思想名錄。任國際期刊 *International Journal of Heat and Mass Transfer* 主編與 *Energy & Environmental Science* 顧問編委。趙教授持續研究新能源儲能理論、技術及應用 30 餘年。以熱物理與電化學學科交叉為主線，建立了流體電池熱質傳遞 - 電化學反應耦合理論。趙教授提出了本項目中液態電能載體儲能新方法，取得了系統的創新成果。

邵敏華教授自 2022 年 1 月起擔任項目統籌人。前項目統籌人趙天壽教授留在項目團隊中，繼續為項目做出貢獻。

邵敏華教授現任香港科技大學張英燦能源工程及環境學教授，化學及生物工程學系講座教授及科大能源研究院院長。他先後於廈門大學獲得理學學士及碩士學位，其後赴紐約州立大學深造，2006 年獲得博士學位。邵教授在加入香港科大前，先後於 UTC Power 及福特汽車公司任職，研究燃料電池及鋰離子電池。在 UTC Power 任職期間，他被晉升為 UTC Technical Fellow（工程系列最高職稱）。 邵教授專研可用於能量轉換

Scientific Board Meeting (November 22,2018)
研究團隊會議 (2018 年 11 月 22 日)

HKUST, Professor SHAO worked at UTC Power on fuel cells and at Ford Motor Company on lithium-ion batteries in the United States. He was a UTC Technical Fellow during his tenure with UTC Power. Professor SHAO has research interests in advanced materials for energy conversion and storage devices, and he possesses a fundamental understanding of related electrochemical reactions. He has published over 210 peer-reviewed articles and 1 one edited book and has filed over 30 patent applications.

及儲存的先進材料，對電化學反應具深入的理解。他在國際權威期刊發表了 210 多篇研究論文，編輯書籍一本，提交了 30 多項專利申請。

Project Summary 項目概要

- To create an e-fuel energy storage system with electrically rechargeable fuels as the storage medium.
- To develop an electrochemical e-fuel charger that produces e-fuels from the intermittent electricity generated from solar cells and wind turbines.
- To demonstrate an e-fuel power pack that provides a stable and stationary power supply.

- 本研究的目標是建立一種以可充電液體為儲存介質的電燃料能量儲存系統。
- 開發一種電燃料充電系統，將太陽能或風力發電轉換到電燃料。
- 將電燃料用於電燃料放電系統，以實現電燃料到電力的穩定供應。

Abstract 項目簡介

We developed a rechargeable electron-fuel energy storage system that incorporates unique liquid fuels known as e-fuels containing regenerative electroactive species. E-fuels can store intermittent electricity harvested with solar cells and wind turbines and release the electricity wherever and whenever needed. This novel electricity-fuel-electricity conversion system consists of an e-fuel charger that electrochemically converts electricity into e-fuels and e-fuels into electricity using an e-fuel power pack.

Unlike all existing rechargeable battery technologies that operate on either charge or discharge, thus preventing their use as an off-grid power supply, the proposed e-fuel system can simultaneously store and release electricity independent of site. Additionally, the ease of storing and transporting e-fuels makes the e-fuel system an excellent choice not only for grid-scale energy storage, but also for off-grid power supplies to power sites not on the grid. The stand-alone power pack even holds the potential to propel next-generation electric vehicles.

本主題項目開發了一種可充放電的電燃料能量儲存系統，其中包含具有可充放電的液體活性物質（稱為電燃料）。電燃料可以利用充電裝置存儲由太陽能和風能所產生的間歇性電能，並通過放電裝置隨時隨地釋放電力。此嶄新的電燃料電力轉換系統能夠形成從間歇可再生能源到電燃料的完全清潔和可持續的能量循環，最終形成穩定的電力供應。

此項目開發的電燃料系統與現有的可充電電池技術不同。現有的技術在一個時間段下只能單獨充電或者放電，因此無法作為離網電源使用。相反，電燃料系統可以實現獨立地電力存儲和應用。此外，電燃料易於存儲和運輸，使其不僅適用於電網規模的能量存儲，更可用於離網電力供應，具備推動下一代電動車輛的潛力。

Research Impact 研究影響

We have assembled an internationally recognized, cross-disciplinary research team to conduct e-fuel energy storage research in close collaboration with local industrial partners. Along with accomplishing the specific research tasks, this project has made fundamental breakthroughs in the integrated theory of electrochemistry and thermal-fluid sciences, and this technology has been patented and licensed internationally. Three categories of e-fuels, namely inorganic, organic active solvated species, and nanoparticle suspensions (nanofluids) have been explored, and an optimal inorganic e-fuel system has been successfully developed. A smart microgrid integrating 10 kW solar energy and the e-fuel system has been demonstrated, in which the e-fuel charger and power pack can achieve an energy efficiency approaching 85%. The as-developed technology offers a promising solution to enabling the massive adoption of renewable energy, which will alleviate the dependence on fossil fuels, and eventually contribute to the Hong Kong government's carbon neutrality target. So far, over 100 peer-reviewed papers have been published in prestigious journals including Nature Materials and Nature Nanotechnology. Over 20 patent applications have been filed with four granted. The project has trained more than 30 postgraduate students. During this research period, the Project Coordinator and other team members have been actively promoting the research outcomes on various occasions in an effort to seek future collaboration opportunities with other institutions and industry players.

我們組建了一個有國際影響力的跨學科研究團隊，並與本地工業夥伴密切合作，開展了電燃料儲能技術的研究。在完成研究任務的同時，該項目在電化學和熱流科學的耦合理論方面也取得了根本性的突破，該技術已申請國際專利並已獲授權。我們從無機、有機和納米流體電燃料三個方向展開了系統性的研究，進而開發出一種高效長壽命的電燃料儲能系統。在此基礎上我們組裝了可用於小型智能微網的 10 kW 光伏 - 電燃料儲能系統，其中電燃料的充放電效率高達 85%，實現了可再生能源的高效利用。該項目的完成將會打破現有儲能技術的局限，大幅推動可再生能源利用的進程，進而減輕對化石燃料的需求，減少碳排放，最終實現政府碳中和目標的可持續性。到目前為止，本項目已產出 100 多篇具有高影響力的研究論文，其中包括《自然 - 材料》及《自然 - 納米技術》。申請專利 20 餘項，其中四項已獲得授權，並培訓了 30 餘名研究生。此外，本團隊在項目執行期間在國內外不同場合發表研究成果，並積極尋求與工業界的技術合作，期望盡早實現項目成果的技術轉化。

Visit by Mr. Paul Mo Po Chan, Financial Secretary of Hong Kong SAR Government (January 29, 2019)
香港特別行政區財政司司長陳茂波先生到訪 (2019 年 1 月 29 日)

Frontier in Energy Storage Conference (June 6-8, 2018)
儲能前沿會議 (2018 年 6 月 6-8 日)

Photochemical Air Pollution in Highly Urbanized Subtropical Regions: From Micro Environments to Urban-terrestrial-oceanic Interactions

亞熱帶城市群區域大氣光化學污染：從微環境到城市 - 陸地 - 海洋的相互作用

T24-504/17-N

Project Coordinator 項目統籌人
Professor Tao WANG 王韜教授
The Hong Kong Polytechnic University 香港理工大學

Participating Institutions 參與院校
The Chinese University of Hong Kong 香港中文大學
The Hong Kong University of Science and Technology 香港科技大學
The University of Hong Kong 香港大學

Professor Tao WANG and his research team
王韜教授及其研究團隊

Short Biography of Project Coordinator 項目統籌人簡介

Professor Tao WANG is a Chair Professor of Atmospheric Environment at The Hong Kong Polytechnic University. He researches the chemistry of the natural and polluted atmosphere and urban and regional air quality. He was the chief scientist for China's Key Basic Research Program ('973 Program') project on acid rain and led several other large research projects funded by Research Grants Council, National Natural Science Foundation of China, and Environment and Conservation Fund. He is an editor of *Atmospheric Chemistry and Physics*, vice-chair of Atmospheric Environment Division and the Ozone Control Commission of China Environmental Science Society, scientific advisor of the Hong Kong Observatory, and on the Air Science and Health Taskforce for Review of HK Air Quality Objectives. He received PolyU President's Awards for Excellent Performance/ Achievements in Research in 2019.

王韜教授是香港理工大學土木及環境工程學系講席教授。主要研究方向為自然和污染大氣化學，及城市和區域空氣質量。他作為首席科學家完成了國家重點基礎研究計劃（973計劃）酸雨項目，並主持多項香港研究資助局、國家自然科基金委員會、和環境及自然保育基金資助的大型研究項目。他目前擔任《Atmospheric Chemistry and Physics》編輯、中國環境科學學會大氣環境分會和臭氧污染控制專業委員會副主任委員、香港天文台科學顧問，以及香港環境局檢討空氣質素指標大氣科學與健康工作組成員。他於 2019 年榮獲香港理工大學校長特設卓越表現 / 成就獎（研究）。

Project Summary 項目概要

- Assessed recent trends of air pollution and found worsening ozone pollution in urban areas despite improvements for other pollutants;
- Quantified emission factors of reactive nitrogen (HONO and NO) from soils and of organic gases from trees; developed/assessed anthropogenic and oceanic chloride emissions; found underestimate of soil emissions and overestimate in biogenic emissions in previous studies;
- Developed state-of-the-art techniques to measure the OH radical and halogen-atom precursors and deployed them in the field to understand their roles in the production of ozone; discovered high levels of reactive halogens (Cl_2, BrCl, and Br_2) in polluted continental and coastal regions and their impact on the atmospheric oxidative power and production of secondary pollutants; conducted lab experiments to reveal nitrate photodissociation as a source of reactive halogens;

- 評估了香港及區域空氣污染的趨勢，發現在其他污染物持續改善情況下城市地區的臭氧污染仍在惡化；
- 量化了土壤的活性氮（HONO 和 NO）和樹木的有機氣體的排放因子；開發、評估了人為源和海洋源的氯排放；揭示了早期研究低估了土壤排放和高估了生物排放；
- 開發了最先進的技術來測量 OH 自由基和鹵素原子前體物，並將這些技術應用到外場觀測，以研究這些活性物質在臭氧生成中的作用；在污染嚴重的內陸和沿海地區發現了高濃度的活性鹵素（Cl_2，BrCl，和 Br_2），並闡明了它們對大氣氧化性和二次污染物生成的重要影響；通過開展實驗室研究，揭示了硝酸鹽光解是活性鹵素的重要來源；

Comprehensive field study at the Hok Tsui Supersite
香港鶴咀空氣質量超級站綜合外場觀測實驗

Experimental set-up of PAM OFR-Chamber system to study volatile organic compound oxidation and secondary organic aerosol formation
實驗裝置，用於研究揮發性有機物的氧化和二次有機氣溶膠的形成

- Developed a Reactor-Chamber facility and conducted experiments to probe the complex products from oxidation of organic gases; conducted comprehensive field studies in Hong Kong concurrently with mainland sites; revealed an important formation pathway of organic particulate via condensation of photochemistry-produced organic vapours, a biomass-burning tracer (OHDCA), and other organics;
- Developed building-resolved and high-resolution (100x100m) air quality models and applied them to simulate airflow and chemistry-dynamics coupling in Hong Kong with high-density buildings and complex terrains;
- Improved physical and chemical schemes (deposition, HONO, N_2O_5, and halogen chemistry) in regional air quality models (WRF-Chem and CMAQ) and applied them to identify pollution sources in HK and mainland cities and to evaluate control measures;
- Evaluated efficacy of Hong Kong's Clean Air Plan, China's Air Pollution Prevention and Action Plan, and unplanned emission reductions during Covid-19 lockdowns; found complex responses of ozone and secondary aerosols (which could either decrease or increase) to emission reductions and important roles of meteorology in evaluating short-term air quality change; recommended control of VOCs alongside current control of NO_x, SO_2 and PM;
- Published >70 papers in peer-reviewed journals, including Nature Geoscience, Nature Communications, and National Science Review; recommended control measures to Hong Kong and mainland environmental agencies and disseminated findings in news media.

- 開發了流動反應器 - 煙霧箱實驗裝置，並研究了有機氣體氧化所產生的複雜產物；通過在香港和內地多個站點開展的綜合外場觀測，揭示了光化學反應產生的有機蒸氣凝結、生物質燃燒示蹤產物（OHDCA），以及其他有機產物對二次有機氣溶膠形成的重要作用；
- 開發了能分辨建築物和 100 x 100 m 空氣質量模型，並將其應用於模擬香港高密度建築和複雜地形影響下的氣流和動力學 - 化學耦合作用；
- 優化了區域空氣質量模型（WRF-Chem 和 CMAQ）中的物理、化學機制（沉降、HONO、N_2O_5 和鹵素化學等），並將其應用於香港和內地城市的污染源的識別及控制措施的評估；
- 評估了香港清潔空氣計劃、中國大氣污染防治和行動計劃、以及 Covid-19 期間的污染物減排效果；揭示了臭氧和二次氣溶膠（增加或減少）對減排的複雜的響應機制，以及氣象條件在評估短期空氣質量變化中的重要作用；建議在控制 NO_x、SO_2 和 PM 排放的同時，增加對 VOC 排放的控制；
- 在 Nature Geoscience、Nature Communications 和 National Science Review 等國際主流學術期刊發表論文 70 餘篇；向香港及內地環保部門提供空氣污染控制措施的建議，研究成果也向新聞媒體和公眾公布。

Abstract 項目簡介

This project consists of comprehensive research investigating photochemical air pollution-a pressing environmental problem in the world's urban and industrialized regions, including Hong Kong. Ozone and fine particulate are major air pollutants. Since January 2018, the project has conducted a series of coordinated laboratory, field, and numerical studies. The major scientific achievements made thus far include the discoveries of the important roles of halogen atoms in air quality in polluted regions, the new source/production pathway of organic particulate matter, and the complex responses of secondary air pollutants to emission controls. Based on the findings, the project has recommended additional measures to mitigate winter haze in north China and photochemical smog in south China. The findings have been disseminated to news media to promote public awareness of the importance of academic research and the current air pollution.

此項目對大氣光化學污染，世界城市和工業化地區（包括香港）所面臨的緊迫環境問題進行了綜合研究。其中，臭氧和細顆粒物是主要的大氣污染物。自 2018 年 1 月以來，此項目開展了一系列聯合實驗室分析、外場觀測，和數值模擬的綜合研究。迄今為止取得的主要科學成果包括：揭示了鹵素在污染地區空氣質量中的重要作用，闡明了有機顆粒物的新來源 / 產生途徑，以及二次污染物對排放控制的複雜反應。根據這些研究成果，此項目建議採取額外的措施來緩解中國華北冬季的霧霾和華南的光化學煙霧污染。研究成果也向新聞媒體和公眾公布，提高了公眾對學術研究的重要性和當前空氣污染的認知。

Research Impact 研究影響

Knowledge: Discovery of photoliable halogen gases that aggravate photochemical pollution in polluted regions and production pathways of organic fine particulates, emissions of reactive gases from subtropical plants and soils; publications in high-impact journals.

Policy: Need to control volatile organic compounds (VOCs) alongside other pollutants in the Mainland; enhancing control aromatics in Hong Kong; consider regulating halogen emissions.

Capacity: The comprehensive emission inventory and improved models allow accurate air quality forecast; trained PhD and postdocs take up academic, governmental, and industrial posts.

知識：發現了光敏鹵素氣體對污染地區光化學污染的加劇、有機細顆粒物的生成途徑、亞熱帶植物和土壤的活性氣體排放；在高影響力期刊上發表學術論文。

政策：內地在控制其他大氣污染物排放的同時，需要加強對揮發性有機化合物（VOCs）的控制；香港需要加強對芳香烴有機化合物的排放控制；並應考慮控制鹵素的排放。

能力：全面詳盡的排放清單和優化的模式可以提高空氣質量模擬和預測的準確性；項目培訓了博士和博士後，他們已於學術界、政府和工業界擔任重要職位。

Design of a semi-open dynamic chamber to measure biogenic volatile organic compound emissions from Eucalyptus trees in Yangchun, Guangdong
半開放動態箱裝置，用於測量廣東陽春桉樹生物揮發性有機物排放量

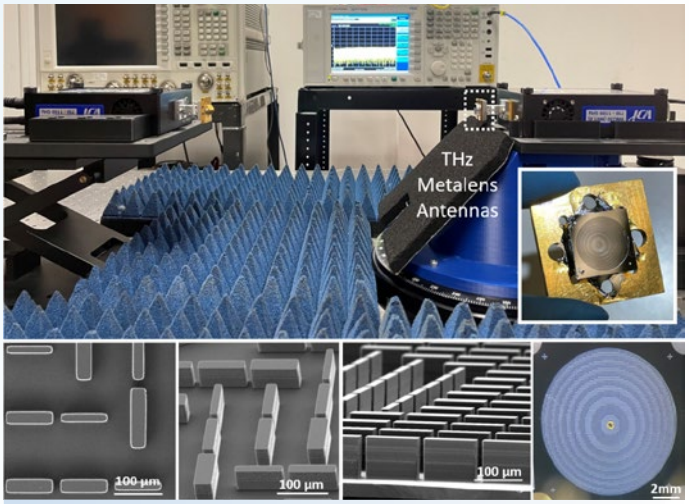
Introducing project findings to Mr Kam-sing WONG (the then Secretary for the Environment) & Mr Alfred Wing-hang SIT (the then Secretary for Innovation and Technology) in PolyU lab on October 19, 2021.
2021 年 10 月 19 日在理大實驗室向黃錦星先生（時任環境局局長）及薛永恒先生（時任創新科技局局長）介紹項目成果

A Compact System for Terahertz Imaging and Spectroscopy
用於太赫茲光譜和成像的小型化系統設計

T42-103/16-N

Project Coordinator 項目統籌人
Professor Chi-hou CHAN 陳志豪教授
City University of Hong Kong 香港城市大學

Participating Institutions 參與院校
The University of Hong Kong 香港大學



Terahertz Metalens Antenna
太赫茲超透鏡天線

Short Biography of Project Coordinator 項目統籌人簡介

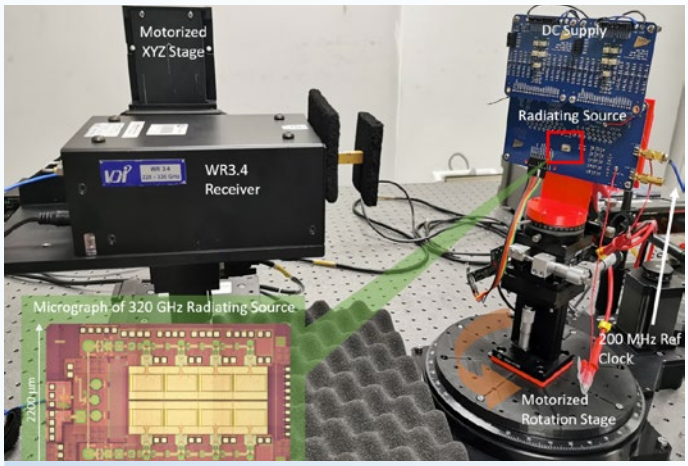
Professor Chi-hou CHAN received his Ph.D. degree in electrical engineering from the University of Illinois at Urbana-Champaign (UICU), USA, in 1987. Before joining the City University of Hong Kong (CityU) in 1996, he was a tenured Associate Professor with the Department of Electrical Engineering, University of Washington, Seattle, WA, USA. He was promoted to Chair Professor of Electronic Engineering in 1998 and is currently Director of the State Key Laboratory of Terahertz and Millimeter Waves and Talent and Education Development Office at CityU. Professor Chan was elected a Fellow of Institute of Electrical and Electronics Engineers (IEEE) in 2002. He received the 2019 Harrington-Mittra Award in Computational Electromagnetics from the IEEE Antennas and Propagation Society and the 2019 Distinguished Alumni Award from the Department of Electrical and Computer Engineering, UIUC.

陳志豪教授於 1987 年在美國伊利諾伊大學 - 香檳分校（UIUC）獲得電子工程博士學位。在 1996 年加入香港城市大學（城大）之前，他是美國華盛頓大學西雅圖分校電子工程系副教授。他於 1998 年晉升為電子工程系講座教授，現為城大太赫茲及毫米波國家重點實驗室和城大優才及教育發展處主任。陳教授于 2002 年當選為電機暨電子工程師學會 (IEEE) 會士。他獲得了 IEEE 天線和傳播協會頒發的 2019 年計算電磁學 Harrington-Mittra 獎和 UIUC 電子和電機工程系頒發的 2019 年傑出校友獎。

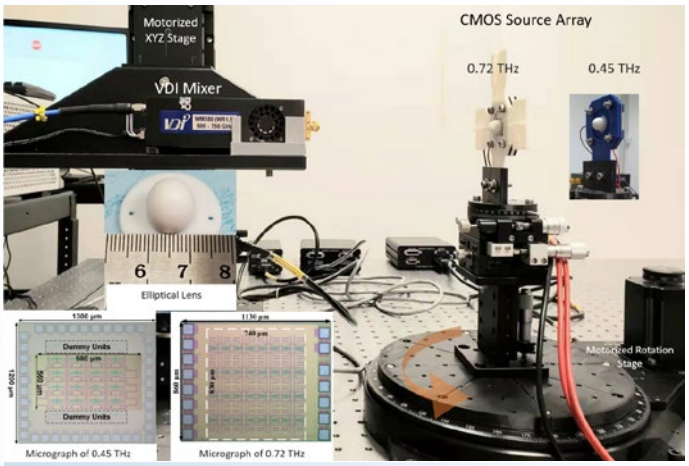
Project Summary 項目概要

- A compact Terahertz (THz) system for imaging and spectroscopy;
- THz spectral libraries for chemical and biological compounds; and
- Fundamental science generated in creating the compact system as archived in highly reputable journals.

- 用於成像和光譜學的緊湊型太赫茲系統；
- 用於化學和生物化合物的太赫茲光譜庫；以及
- 在創建緊湊型系統的過程中研發基礎科學，並在高知名度的期刊中發表成果。



320 GHz Phased Array IC
320 GHz 相控陣芯片



Terahertz Scalable Radiator Array
太赫茲可擴展幅射陣列芯片

Abstract 項目簡介

Terahertz (THz) wave is in the electromagnetic spectrum between the conventional microwave and infrared regions with a wide range of applications. Penetration of THz wave is susceptible to water molecules and can distinguish intrinsic contrast between normal and cancerous tissues. When used in imaging, foreign objects in drugs and foods can be conveniently detected.

Researchers hoping to exploit this promising frequency regime must confront the enormous entry barriers attributed to the cost of the testing equipment and the availability of THz sources with sufficient power.

A low-cost, compact THz system for imaging and spectroscopy can accelerate THz research and resolve more burning issues affecting our welfare. Our synergistic effort will bring advances in high-resolution imaging, material inspection for high value-added manufacturing, and food safety.

太赫茲（THz）波是在傳統的微波和紅外區域之間的電磁波譜，具有廣泛應用。太赫茲波的穿透力雖容易受到水分子的影響，但可用來區分正常和癌變組織。當用於成像時，藥物和食品中的異物便可方便地被檢測出來。

在利用該前瞻性的頻率資源時，研究人員面臨着巨大的研究障礙，這些障礙歸因於高額的測試設備成本和缺乏具有足夠功率的可用太赫茲源。

用於成像和光譜學的低成本、緊湊型太赫茲系統可加速太赫茲研究，並解決很多影響我們的緊迫問題。我們的共同努力將為高解析度成像、高增值製造業的材料檢測和食品安全帶來發展。

Research Impact 研究影響

We have developed low-cost, high-power THz sources based on the scalable coupled oscillator-radiator array architecture implemented by 65-nm complementary metal-oxide-semiconductor (CMOS) technology. These chips comprise synchronized oscillators at the fundamental frequency with the desired harmonic signals radiating coherently for high output power.

Our second-harmonic chip operating at 0.45 THz incorporated with a low-cost Teflon lens yields the highest effective isotropic radiated power (EIRP) of 28.2 dBm. The 0.7-THz third-harmonic chip achieves the highest -3-dBm output power among all the coherent, scalable radiator Integrated Circuit (IC) beyond 0.6 THz.

We also developed beam steering chips at 0.32 THz with a scanning range of ±30°. These THz sources enable the replacement of the bulky waveguide-based setup feeding the THz antennas and devices we developed for THz Mueller matrix imaging and beam manipulation. We successfully demonstrated space-time-coding metasurface antennas that can manipulate polarization, amplitude, frequency, beam direction, and phase of the antennas' radiation through sequences of on-off switching of the meta-atoms. This disruptive technology provides new perspectives in imaging and communications. Although designed at 27 GHz for proof of concept, frequency scaling of the antenna to THz frequencies can be achieved through CMOS technology.

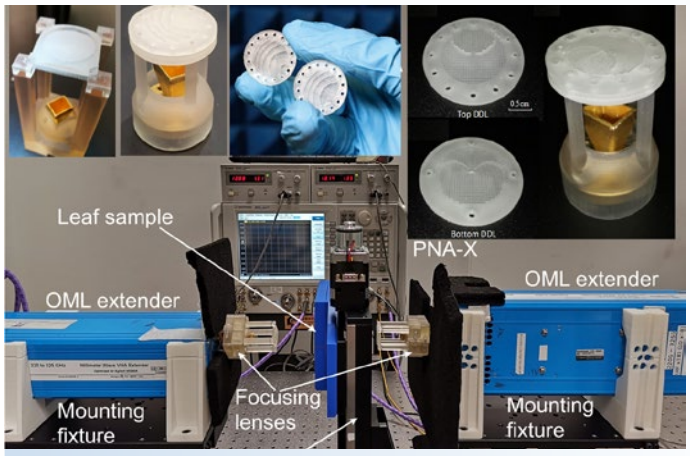
Applications of THz technology are not limited to imaging and spectroscopy but also in the future 6th generation (6G) of wireless communications. We have developed THz-optic modulators to modulate THz signals into optical carrier frequencies efficiently. Therefore, the long-haul transmission of THz signals is made possible through optical communications networks. The fabricated thin-film lithium niobate modulator has a measured 3-dB electro-optic bandwidth of 170 GHz and a 6-dB bandwidth of 295 GHz. With further incorporation of mixers, amplifiers, etc., into our THz radiator ICs, the outputs of this project pave the way for our future demonstration of 6G wireless communications.

我們研發了低成本、高功率的太赫茲源，它基於可擴展的耦合振盪器 - 輻射器陣列結構，由 65 納米互補金屬氧化物半導體（CMOS）技術實現。這些晶片由基頻的同步振盪器組成，所需的諧波信號以相干方式輻射以獲得高輸出功率。

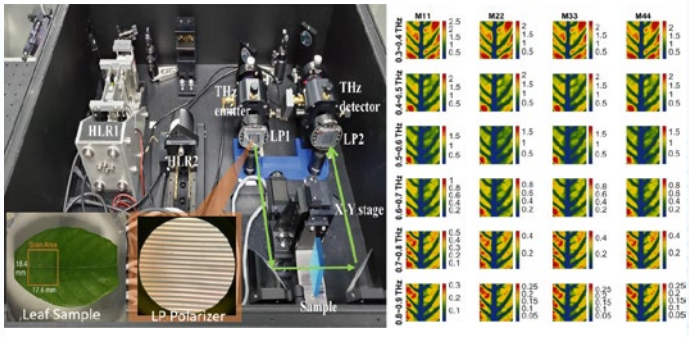
我們的第二諧波晶片運作在 0.45THz，與低成本的特氟隆透鏡結合，產生的最高有效各向同性輻射功率（EIRP）為 28.2dBm。0.7THz 的第三諧波晶片在所有高於 0.6THz 的相干、可擴展的輻射器集成電路中實現了最高的 -3-dBm 輸出功率。

我們還研發了 0.32THz 的波束掃描晶片，掃描範圍為 ±30°。這些太赫茲源能取代笨重的基於波導的設置，為太赫茲天線和我們開發的太赫茲穆勒矩陣成像和光束操縱裝置提供能源。我們成功地展示了空間 - 時間 - 編碼的超構表面天線，可以通過單元的開關序列來操縱天線輻射的偏振、振幅、頻率、光束方向和相位。這項顛覆性技術為成像和通信提供了新的視角。儘管為了驗證概念而設計在 27GHz，但通過 CMOS 技術可以將天線的頻率擴展到太赫茲頻率。

太赫茲技術的應用不僅限於成像和光譜學，還包括未來第六代（6G）無線通信。我們已經開發了太赫茲光學調製器，將太赫茲信號有效地調製成光載波頻率，使得太赫茲信號在光通信網絡的長距離傳輸成為可能。我們製造的鈮酸鋰薄膜調製器在 170GHz 及 295GHz 時分別具有 3dB 及 6dB 電光頻寬。隨著混頻器、放大器等進一步融入我們的太赫茲輻射器 IC，本項目的產出為我們未來展示 6G 無線通訊鋪平了道路。



Terahertz Lens Antennas and Imaging System
太赫茲透鏡天線和成像系統



Multi-spectral Terahertz Mueller Matrix Imaging
多光譜太赫茲穆勒矩陣成像

Learning and Assessment for Digital Citizenship
數碼世代公民素養的學習和評估

T44-707/16-N

Project Coordinator 項目統籌人
Professor Nancy Wai-ying LAW 羅陸慧英教授
The University of Hong Kong 香港大學

Participating Institutions 參與院校
The Hong Kong University of Science and Technology 香港科技大學

Photo of Professor Nancy LAW with some members of the project team and the project advisory committee at the International Education Expo at Zhuhai, November 2019.
2019 年 11 月，在珠海國際教育博覽會上，羅陸慧英教授與研究團隊及項目咨詢委員會部分成員合影。

Short Biography of Project Coordinator 項目統籌人簡介

Professor LAW is a professor in the Faculty of Education at The University of Hong Kong (HKU), and an elected Fellow of the International Society of the Learning Sciences. She served as the Founding Director for the Centre for Information Technology in Education (CITE) from 1998 to 2013. She led the Science of Learning Strategic Research Theme at HKU (2013- 2017) and received a "Humanities and Social Sciences Prestigious Fellowship Scheme Award" from the Research Grants Council in 2014 in recognition of her research in scalability of technology-enhanced learning innovations.

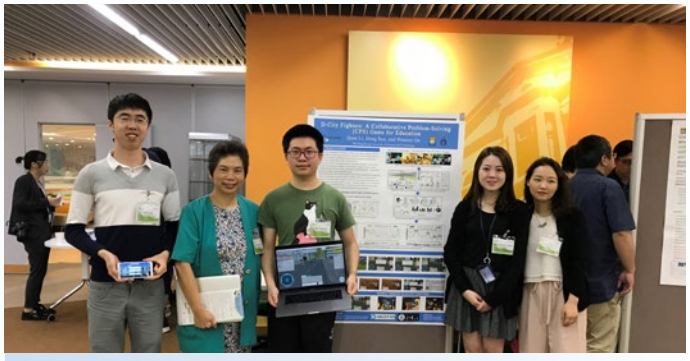
羅陸慧英教授為香港大學教育學院教授，國際學習科學學會當選會員。她是港大資訊科技教育中心（CITE）的創會主任（1998-2013），香港大學學習科學策略研究主題（2013-2017）的召集人。她在科技促進學習創新的可擴展性方面的研究於 2014 年獲香港特別行政區研究資助局頒發“人文及社會科學傑出獎學金計劃”。

Project Summary 項目概要

- The grand challenge for this project was to understand and improve the development of digital citizenship as a multifaceted human capacity from childhood to early adulthood. In terms of human capacity, the project investigated two core competences—digital literacy (DL) and collaborative problem solving (CPS) that are crucial for digital citizens to exercise their rights and responsibilities in a world where the digital and physical actions, interactions, and interconnections are intricately integrated.
- There are two cross-cutting themes throughout the project and its components: understanding and supporting the wellbeing and development of children and youth as digital citizens. At the core of the project is a longitudinal panel study involving 3 age cohorts (7-10, 11-14, 15-18); the main data collection was conducted in the second half of the 2018-19 and 2020-21 academic years. Assessment of key 21st century skills, including DL and CPS and a survey on students' digital technology use patterns, self-efficacy, self-reported wellbeing, personal, family and school background are included in the longitudinal study.

- 此項目要解決的重大挑戰是理解和改善數碼公民作為從童年到成年早期的多維人類能力的發展。項目調查了兩項核心能力——數碼素養（DL）和協作解難（CPS），這兩項能力對於數碼公民在現實與虛擬世界的錯綜複雜互動及相互聯繫中行使權利和履行責任至關重要。
- 整個項目及其組成部分有兩個跨領域的主題：理解和支持兒童和青少年作為數碼公民的福祉和成長。此項目的核心是一項縱向隊列研究，涉及 3 個年齡組別（7-10、11-14、15-18 歲）：主要數據在 2018-19 和 2020-21 學年的下半年收集。該縱向研究囊括了對 21 世紀關鍵技能的評估，包括數碼素養和協作解難能力，以及對學生數碼科技應用模式、自我效能感、自我報告幸福感及個人、家庭和學校背景的調查。

A student explaining their group's game design
一名學生解釋他們小組的遊戲設計



PhD and Master students from HKU and The Hong Kong University of Science and Technology jointly working on the design and implementation of the online role play game"D-City fighters" to foster anti-cyberbullying awareness and handling strategies.
香港大學與香港科技大學的博士及碩士生合作設計及實施 “D-City fighters” 網絡角色扮演遊戲，以培養反網絡欺凌意識及處理策略。

- Additional project components include: (1) using mobile and wearable devices to investigate students' learning lives within and outside of the school; (2) developing and using online role play games to support learning and assessment of collaborative problem solving; (3) developing and evaluating advanced AR/VR technologies to enhance online learning interactions, including socioemotional communications/interactions and virtual experiments.
- The key findings from this project include: (1) there were overall improvements in DL from 2019 to 2021, but the performance gap in DL also widened; (2) students' social CPS skills dropped slightly, while students' cognitive CPS skills remained relatively unchanged over time; (3) digital competence was a protective factor against negative online experiences, contributing to digital wellbeing; (4) civic participation by young adults was differentiated by the nature of the activity rather than the mode (online or offline) of participation. Online and offline participation reinforce each other; (5) school leadership that fosters a culture of trust, collaboration, and openness to innovation with a broad-based school e-learning team is crucial for online learning preparedness and resilience.
- Important additional outcomes from the project include a suite of robust assessment instruments and innovative research methodologies for researching digital citizenship, and advanced learning technologies and programs for the learning and assessment of digital citizens.

- 其他項目組成部分包括：(1) 使用移動和可穿戴設備調查學生在學校內外的學習生活；(2) 開發和使用線上角色扮演遊戲，以支持學習和評估協作解難能力；(3) 開發和評估先進的 AR/VR 技術，以增強線上學習的互動性，包括支援社會情感交流 / 互動和進行虛擬實驗。
- 本研究的主要發現包括：(1) 學生數碼素養的總體水平在 2019 至 2021 間有所提高，但鴻溝也在擴大；(2) 學生的協作解難社交技能在兩年內略有下降，而認知技能則相對保持不變；(3) 數碼能力是對抗負面網絡經驗的保護因素，有助於促進數碼福祉；(4) 青少年的公民參與不是因參與模式（線上或線下）而有所區分，而是因活動的性質有所區別。同時，線上和線下的參與能相互加強；(5) 學校領導層培養信任、合作和開放創新的文化，建立一個基礎廣泛的學校電子學習團隊，對為網上學習作好準備和增強抗逆能力至關重要。
- 此項目取得的其他重要成果包括一套用於研究數碼公民的嚴謹、穩健評估工具和創新研究方法，以及用於學習和評估數碼公民的先進學習科技和學習資源。

Abstract 項目簡介

This project is an interdisciplinary research project to study the impact of digital media on the everyday life of children and youth, and on their development as citizens in an increasingly technology-intensive and globally-connected world. The longitudinal study conducted in the first half of respectively 2019 and 2021 found:

- A serious digital literacy (DL) divide within and across schools that greatly increased over time.
- Students' collaborative problem-solving (CPS) skills suffered during the pandemic.
- Students' socioeconomic status (SES) influences their DL, but only at the school level, meaning that students in schools with above average SES are advantaged, but individual students' SES does not affect their DL achievement in comparison with other students from the same school.
- Digital literacy is a protective factor for students' wellbeing, namely Internet & game addiction, proneness to cyberbullying experience, online safety and data privacy issues.
- Students' DL achievement are positively predicted by their digital leisure activities at home and their engagement in exploratory schoolwork (e.g. search for information), but not by teacher-directed learning tasks.
- A good parent-child relationship is the single most important factor for a child's wellbeing.
- Schools with high levels of online learning preparedness share similar leadership characteristics in developing a culture of trust, collaboration, and openness to innovation.
- Schools' participation in joint-school student-centered learning innovation projects is beneficial to their online learning preparedness.

本項目是一項跨學科的研究項目，旨在研究數碼媒體對兒童和青少年日常生活的影響，以及在科技日益普及、全球聯繫日益緊密的世界中，對他們作為公民的發展產生的影響。在 2019 年上半年和 2021 年上半年進行的縱向研究發現：

- 隨著時間的推移，學校內部和校際之間存在着嚴重的數碼素養 (DL) 鴻溝。
- 學生的協作解難能力（CPS）在疫情期間受創。
- 學生的社經地位（SES）影響他們的數碼素養，但僅在校際層面起作用，意味著在整體社經地位較高的學校就讀的學生有較好的數碼素養表現，但與同一學校的其他學生相比，個別學生的社經地位並不影響他們的數碼素養表現。
- 數碼素養是學生福祉的保護因素，在一定程度上保護其免受上網 / 遊戲成癮、網絡欺凌、網絡安全和數據隱私問題的負面影響。
- 學生在家中的數碼消閒活動和探索式學習活動（如搜尋資料）對他們的數碼素養表現有正向預測作用，而由教師嚴格指導的學習則沒有此作用。
- 良好的親子關係是學生福祉的最重要影響因素。
- 在線學習準備水平高的學校都具相似的領導特徵：都能培養信任、合作和開放創新的校園文化。
- 學校參與以學生為中心的聯校學習創新項目，有助為線上學習作好準備。

Research Impact 研究影響

- On policy (government and school levels) and the community: the need to take account of the findings to create appropriate conditions and support to foster students' digital literacy and digital wellbeing. Evidence: the spinoff project on "eCitizen Education 360 - an action focused post-COVID-19 study for equitable quality education for all" was successfully launched in June 2020, made possible with wide community support. School-based reports helped schools to reflect and make further strategic plans for a better New Normal in education.
- The tools and instruments developed through the project will have significant impact on educational policy and practice. Schools, youth organizations and charitable organizations are currently exploring collaboration with the research team to use the instruments and the team's research expertise to support their strategic development projects.
- Further impact is expected in the areas of parent education, social policy, as well as the e-learning industry.

- 政策（政府及學校層面）和社區方面：本項目的研究成果指出了提供適當條件和支援以培養學生的數碼素養和福祉的重要性。具體例證：在社會廣泛支持下，衍生項目「數碼素養 360 - 以行動為本的疫後研究 推動全民優質教育」於 2020 年 6 月成功啟動。該項目的校本報告有助於學校反思和制訂進一步的策略規劃，以訂立更好的教育新常態。
- 項目開發的評估工具將對教育政策和實踐產生重大影響。一些學校、青年組織和慈善組織目前正與項目團隊商討研究合作，利用評估工具和團隊的研究專長來支持他們的策略發展項目。
- 長遠貢獻：預計長遠將進一步惠及家長教育，社會政策以及數碼學習科技行業等領域。

Big Data for Smart and Personalized Air Pollution Monitoring and Health Management

大數據為本智能及個人化空氣污染監測和健康管理

T41-709/17-N

Project Coordinator 項目統籌人
Professor Victor On-kwok LI 李安國教授
The University of Hong Kong 香港大學

Participating Institutions 參與院校
The Hong Kong University of Science and Technology 香港科技大學
The University of Cambridge 劍橋大學

Project team members at the launching ceremony of the TRS project officiated by Vice-Chancellor (VC) of the University of Hong Kong (HKU) and Cambridge University Deputy VC in August 2017
研究團隊於 2017 年 8 月出席由香港大學校長和劍橋大學副校長主持的“主題研究計劃”項目啟動典禮。

Short Biography of Project Coordinator 項目統籌人簡介

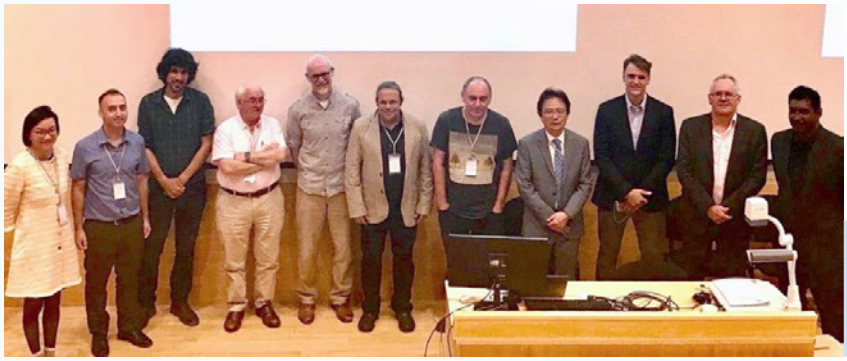
Professor Victor LI is Chair of Information Engineering and Cheng Yu-Tung Professor in Sustainable Development at the Department of Electrical and Electronic Engineering (EEE) of The University of Hong Kong (HKU), and Director of HKU-Cambridge Artificial Intelligence (AI) to Advance Well-being and Society Research Platform. He was the Head of EEE, and Assoc. Dean (Research) of Engineering at HKU. His research interests include big data, AI, optimization techniques, and interdisciplinary environment and health studies. He received SB, SM, EE and ScD degrees in Electrical Engineering and Computer Science from the Massachusetts Institute of Technology in 1977, 1979, 1980, and 1981, respectively. Previously, he was Professor of Electrical Engineering at the University of Southern California (USC), Los Angeles,California, USA, and Director of the USC Communication Sciences Institute. He is a Fellow of the Hong Kong Academy of Engineering Sciences (HKAES), Institute of Electrical and Electronic Engineers (IEEE), and Hong Kong Institution of Engineers (HKIE), and a United Kingdom Royal Academy of Engineering Senior Visiting Fellow.

李安國教授為香港大學電機及電子工程學系鄭訊息工程講座教授、鄭裕彤基金教授（可持續發展）及香港大學 - 劍橋大學人工智能促進社會福祉研究平台總監。他亦曾任香港大學電機及電子工程學系系主任及工程學院副院長（研究）。李教授的研究領域包括大數據、人工智能、優化技術以及跨學科環境與健康研究。他分別於一九七七年、一九七九年、一九八零年及一九八一年獲美國麻省理工學院理學士、理學碩士、工程師及理學博士學位。李教授亦曾任美國洛杉磯南加州大學電機工程教授及南加州大學通訊科學研究所所長。他亦是香港工程科學院、電機電子工程師學會、香港工程師學會院士及英國皇家工程學院高級訪問學者。

Project Summary 項目概要

- Develop a big data framework for smart and personalized air pollution monitoring and health management based on a deep learning model.
- Collect real-time, interactive, personalized and synchronized air pollution, activity, health condition, health perception, and behavior data.
- Develop smartphone apps UMeAir, to enable real-time, interactive air pollution monitoring and health management, and personalized alert and advice to our citizens.
- Determine the causal relationship between personal exposure to $PM_{(1.0,2.5)}$, NO_2 and health conditions and health perceptions of young asthmatics and young healthy citizens in HK.
- Develop a smart information-induced behavioral model to determine whether smart information will induce behavioral change, hence facilitating data-driven decision-making.

- 創建一個基於深度學習模型大數據框架用於智能，個人化空氣質量監測和健康管理。
- 收集實時、互動、個人化和同步的空氣污染、活動、健康狀況、生活質素、健康評估及行為數據。
- 創建手機應用程式 UMeAir 向我們的市民提供實時、互動之空氣污染監測和健康管理及個人化提示和建議。
- 確定香港的年輕哮喘病患者和年輕健康公民的個人空氣污染物暴露（尤其是直徑小於或等於1.0微米和2.5微米顆粒物）與個人健康狀況和健康生活質素（幸福感）的因果關係。
- 創建一個智能信息誘導行為模型以確定智能信息是否會引起行為改變，從而促進數據驅動的決策。



AI for Social Good Symposium held at Cambridge University, UK, May 24, 2019, jointly organized by this project, Cambridge University, and HKU-Cambridge AI-WiSe
2019 年 5 月 24 日，人工智能對社會裨益研討會在英國劍橋大學舉行，由本研究項目、劍橋大學和香港大學劍橋 AI-WiSe 聯合舉辦。

Community Outreach to Hong Kong schools: Thematic talks jointly organized by the Hong Kong Academy of Sciences and the Hong Kong Academy of Engineering Sciences, "What is AI and how can it benefit the society?" Also available in Youtube and Facebook channels. (since May 2021)
香港學校社區外展：香港科學院與香港工程科學院合辦的專題講座"什麼是人工智能，它如何造福社會？"，也可以在 Youtube 和 Facebook 頻道中找到。（由 2021 年 5 月起）

AI for Social Good Symposium held at HKU in hybrid mode, May 24, 2021, jointly organized by this project, Cambridge University, and HKU-Cambridge AI-WiSe.
2021 年 5 月 24 日，人工智能對社會裨益研討會在香港大學以混合模式舉行，由本研究計劃項目、劍橋大學和香港大學劍橋 AI-WiSe 聯合舉辦。

Abstract 項目簡介

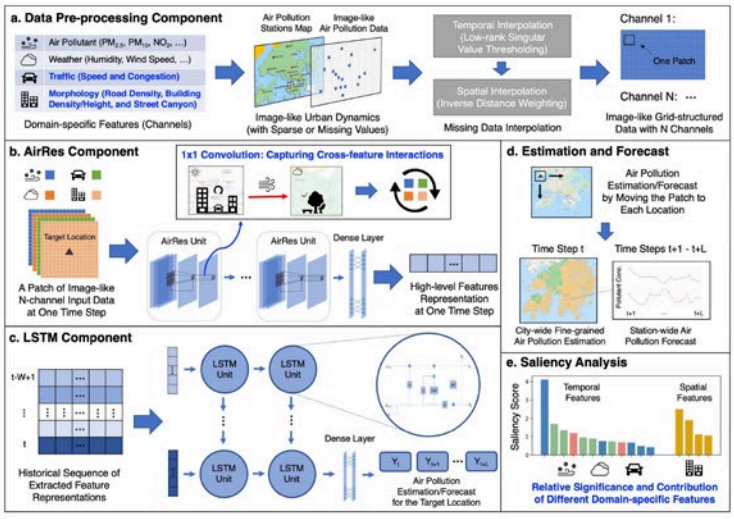
This project, leveraging on international, interdisciplinary expertise in engineering, science, medicine, and social science, develops artificial intelligence and big data technologies to enable the estimation and forecasting of real-time, interactive, air pollution information, to the street level, and to provide personalized alert and advice to improve the health of our citizens. Our developed technologies are deployed in a smartphone apps UMeAir, freely available to all citizens and visitors of Hong Kong. Our technologies can be easily extended to other cities such as Beijing, London, etc., creating new business opportunities and competitive advantage for the information technology and healthcare industry in HK.

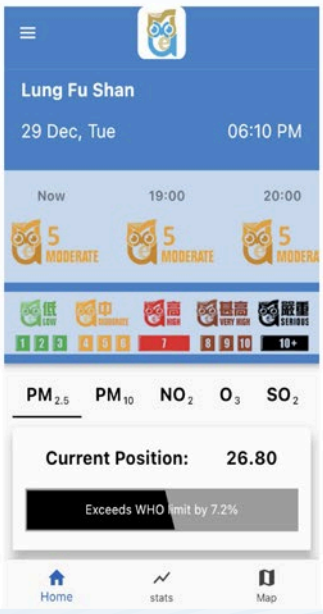
這項目利用工程、科學、醫學和社會科學領域的國際跨學科專業知識，開發人工智能和大數據技術，以實現街道水平實時、互動、空氣污染資訊的估計和預測，並提供個人化的警報和建議，以改善我們市民的健康。我們開發的技術應用在智能手機應用程式 UMeAir 之中，所有香港市民和遊客都可以免費使用。我們的技術可以容易地擴展到北京、倫敦等其他城市，為香港的資訊科技和醫療保健行業創造新的商機和競爭優勢。

Research Impact 研究影響

- Novel big data framework for high precision, real-time, interactive, personalized air quality monitoring and health management, easily replicable to other cities.
- New synchronized heterogeneous datasets.
- Improved citizen understanding and data-driven decision-making.
- Causal relationship between personal exposure (aged 12-18) to $PM_{(1.0,2.5)}$ and health/health perception rigorously investigated via longitudinal exposure study.
- Rigorous personal behavior change study based on actual behavioral data.

- 應用於高精確度、實時、互動、個人化空氣質量監測和健康管理的嶄新大數據框架，可輕易複製到其他城市。
- 嶄新的同步多樣化數據集。
- 提高公民認知及數據驅動的決策。
- 通過空氣污染及健康縱向研究（12-18 歲），調查個人暴露於直徑小於或等於 1.0 微米和 2.5 微米顆粒物與健康狀況及健康生活質素評估的因果關係。
- 根據實際行為數據，嚴謹對個人行為變化進行調查。

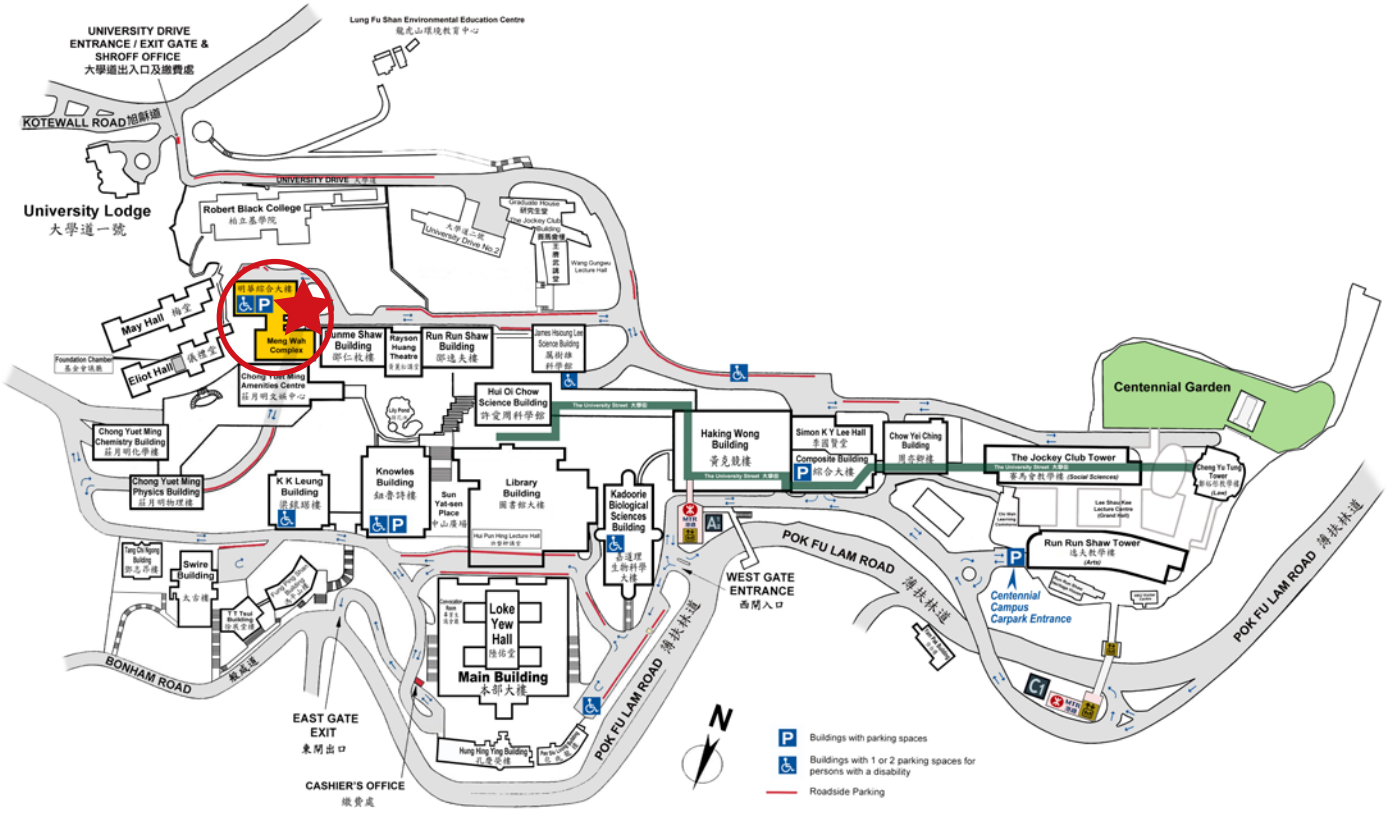




UMeAir screenshot/DeepAIR Model
UMeAir 截圖 /DeepAIR 模型

NOTES 筆記

Location Map
地圖



研討會網頁以及更多詳情
Symposium Website and Symposium details

Organizers 主辦機構

大學教育資助委員會
University Grants Committee

香 港 大 學
THE UNIVERSITY OF HONG KONG

Collaborating Universities 協辦大學

City University of Hong Kong
香港城市大學

The Chinese University of Hong Kong
香港中文大學

The Hong Kong Polytechnic University
香港理工大學

The Hong Kong University of Science and Technology
香港科技大學