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

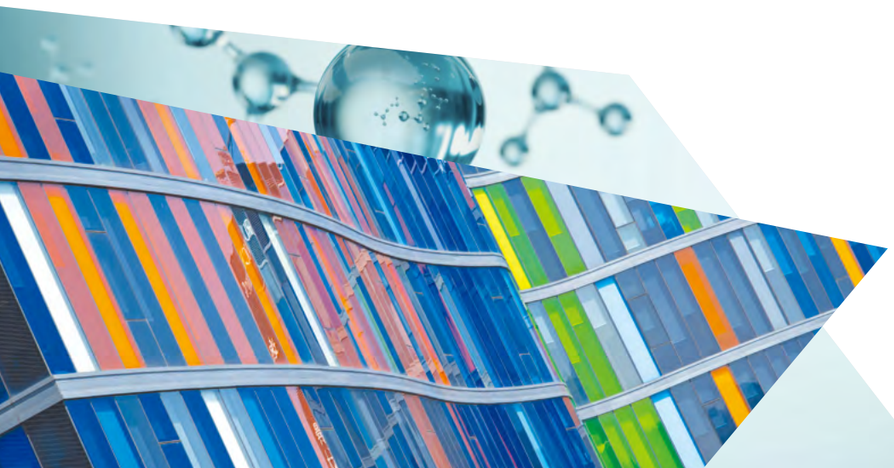
SCIENTIFIC TRAINING and MENTORING

for STEM Talents

Message from **Pro-Vice-Chancellor / Vice-President**

CUHK is not only enthusiastic but also has rich experiences in supporting the school sector to train students of high caliber. The "Scientific Training and Mentoring for STEM Student" programme sponsored by the Gifted Education Fund of Education Bureau is a meaningful endeavor by our Faculty of Science in promoting STEM education. The programme serves to enrich students with the necessary knowledge and skills for STEM development, and to elevate their interests and capabilities in STEM research. I very much hope that students find their participation in the programme rewarding and will continue the exploration of STEM with a view to making contributions to the society.

Professor POON Wai-yin
Pro-Vice-Chancellor / Vice-President
Professor, Department of Statistics
The Chinese University of Hong Kong



Message from **Dean of Science**

Hello Everyone. I would like to thank all the students participating in the programme "Scientific Training and Mentoring for STEM talents" in the Faculty of Science at the Chinese University of Hong Kong. It is my real pleasure to celebrate the achievement that you all have made over these 18 months in this programme launched in summer 2020.

The Faculty of Science at CUHK has long been committed to educate and inspire the next generation of scientific innovators. It is our privilege to embark on the programme funded by the Gifted Education Fund. The 3-tier training programme providing off-school science and mathematics training to gifted talents is a major initiative that the Faculty and the Science Academy for Young Talent have taken to further STEM education. Under the leadership of Professor Kin Ming Kwan in our Faculty, we hope to provide an enriched learning environment and endeavour to enhance students' learning experience through offering modified university level lecture courses and interactive laboratory sessions, and inviting them to participate in research projects with guidance from our faculty members.

I am delighted to be with you today and learn the diverse and interesting research topics that the 14 highly gifted young scientists have worked in today's symposium. We also look forward to welcoming many of you in the near future as new students excited in STEM field in the Faculty of Science at CUHK.

Professor SONG Chunshan
Dean of Science
Wei Lun Professor of Chemistry
The Chinese University of Hong Kong

Message from **Programme Coordinator / Associate Dean (Education) of Science**

Congratulations to all students who have completed the training programme "Scientific Training and Mentoring for STEM Talents" which aims to train gifted students with sound STEM knowledge and gain valuable experience through conducting research under the guidance of academics.

Innovation and technology development was emphasized in the latest policy address and definitely will be the way forward for Hong Kong. I am sure the learning experience you gain in this programme will equip you to face the challenges and prepare yourself to contribute to the future development of our society.

I wish all of you every success in your future endeavour.

Professor KWAN Kin Ming
Programme Coordinator, Scientific Training and Mentoring for STEM Talents
Associate Dean (Education)
Faculty of Science
The Chinese University of Hong Kong

Research Project

The programme serves to enrich students with the necessary knowledge and skills for STEM development, and to elevate their interests and capabilities in STEM research.

LIFE SCIENCES

Knockdown of lncRNA identified by single-cell transcriptomics affects Drosophila melanogaster leg development

CHAN Wai Kiu Bridget
School: Marymount Secondary School
Project Leader: Professor CHAN Ting Fung Philos

The reasons that I join the programme

I am Bridget Chan, a Form 6 student from Marymount Secondary School. I embarked on my journey in STEM since 2017, ranging from designing robotic hands to joining international symposiums, which have fuelled my passion in scientific research. As an aspiring student in the medical field, I wish to further stretch my area of interest to molecular biology and chemistry, subjects that I adore in my secondary school curriculum. The course materials and research topics were undoubtedly advanced. Yet, the failed prototypes and unprecedented adversities that I've once had have equipped me with the perseverance and positive mindset. I've had a fruitful learning experience without regrets, and undoubtedly, nothing would have been possible without the guidance from Prof. Chan and Miss Joyce Tse.

The abstract of my research study

In this study, we have made use of single-cell RNA-sequencing to look into the gene expression of individual cells, which surpasses the traditional bulk RNA-sequencing of a mixture of cell types. In particular, we studied the imaginal disc in Drosophila melanogaster, the larval structures that differentiate into appendages, such as legs and wings, when they mature into adults. Among the genes that exhibited differential expression during leg development, a great majority are protein-coding genes, but one previously uncharacterized long non-coding RNA (lncRNA) gene showed upregulated gene expression, as observed in the distal cells. To investigate its potential functions, we utilized the GAL4/UAS system to generate transgenic flies with disrupted expressions of the lncRNA gene. Within this system, only with the expression of GAL4 will the subsequent genes in UAS be expressed, in turn manipulating the expression of this lncRNA. We observed the leg phenotypes of these transgenic fruit flies and found that the length of their legs, in particular the tibia and tarsal segments, showed significant differences in lengths in the repeated (N=3) measurements compared to the control groups, as verified statistically. These results suggest that this lncRNA is an important regulator in leg growth and development.

CHEMISTRY

Asymmetric Synthesis

CHENG Hiu Yeung
School: Wa Ying College
Project Leader: Professor TSUI Chit Gavin

The reasons that I join the programme

When I found the information about this programme on the website, I was amazed by the plan of this programme. The three-phased training provides courses on various subjects and I am able to choose multiple subjects to explore. The lectures cover advanced knowledge of different areas, including university level knowledge and experiments. Moreover, the training provides chances of research studies which is rare in STEM education programmes. I learnt the use of chemistry apparatuses to support a scientific investigation with help of mentors in the past few months. This experience of research is precious to me as I can prepare my studies in researches better in the future, while the knowledge obtained during the courses assists my studies in university now.

The abstract of my research study

Previous study (Org. Lett. 2020, 22, 4562-4567) have reported the surprisingly high diastereoselectivity in pentafluoroethylation of unactivated alkenes using CuCF2CF3 as CF2CF3 radical source, which was generated from an inexpensive gaseous reagent, HCF2CF3 (pentafluoroethane, HFC-125). Interestingly, the product of radical clock reaction was bis-pentafluoroethylated, instead of the mono-pentafluoroethylated. We thus further investigated the substrate scope of this bis-pentafluoroethylcyclization reaction. Malonate ester substrates were produced by esterification of malonate with corresponding alcohols/phenol followed by deprotonation and nucleophilic substitution with corresponding alkyl bromide. Meanwhile, sulfonamide substrates were synthesized from corresponding sulfonyl chloride and diallyl amine. The produced substrates then underwent pentafluoroethylcyclization using freshly prepared CuCF2CF3. The purity and structures of products were confirmed by NMR and GC-MS analysis, while the sulfonamide substrates gave lower stereoselectivity and yield comparing to the ester ones. However, some of the pure isomers can still be separated by column chromatography. As pure isomers can be easily extracted, the use of this reaction may reduce the cost of manufacture of pure isomer drugs especially when other stereoisomers are harmful.

LIFE SCIENCES

Structural Biology / Structure-based drug design

CHO Sin Ting Athena
School: Diocesan Girls' School
Project Leader: Professor NGO Chi Ki Jacky

The reasons that I join the programme

I have always been fascinated by science, especially in the field of life science. When I first came across the description of the course, the mention of a self-initiated research study was so attractive that I immediately decided to sign up. This course offers a rare opportunity for students to engage in real-life laboratory research while being introduced to advanced, university-level STEM knowledge. From the perspective of a hands-on learner like me, it is an invaluable academic experience that could hone my expertise and skills in different aspects of STEM, preparing me for my further studies.

The abstract of my research study

The protein-protein interaction between the essential splicing factor SRSF1 and its kinases SRPKs could lead to dysregulation of splicing of VEGF and subsequently angiogenesis. A docking groove on SRPK is essential for the binding and phosphorylation of the RS domain of SRSF1. Our lab has previously shown that the interaction between SRSF1 and SRPKs can be inhibited by DBS1, a peptide inhibitor that specifically blocks the docking groove. We have recently optimized DBS1 into DBS1-1, which could covalently bind to the docking groove of SRPK and better prevents the interaction between SRSF1 and SRPK. However, a high concentration of DBS1-1, for instance at a 10:1 ratio of DBS1-1 to SRPK, could lead to nonspecific binding to the substrate SRSF1 instead. Using recombinant technology, we expressed and purified an active construct of SRPK2, SRPK2ΔS1, from *E. coli* and the proteins will be used to investigate whether nonspecific binding of DBS1-1 to SRSF1 will happen at a lower concentration when SRPK2 is present. Protein purification was carried out using immobilised metal affinity chromatography to isolate His-tagged SRPK2ΔS1. On the other hand, a conjugation assay was conducted to test the binding of DBS1-1 and SRSF1 in the absence of SRPK. Results indicate that His-tagged SRPK2ΔS1 can be successfully obtained with a high purity from recombinant *E. Coli* BL21, and nonspecific binding of DBS1-1 and SRSF1, despite to a lower extent, would still occur at a ratio of 3:1.

LIFE SCIENCES

Neuronal Morphology Analyses upon Chronic Alcohol Exposure

FARHAN Ishraq
School: La Salle College
Project Leader: Professor CHOW Hei Man Kim

The reasons that I join the programme

I joined this programme because I hope to become a scientific researcher myself in the future. The programme offered me an experience on what it is like doing novel by participating in a research project as early as while being a secondary school student.

The opportunity to learn about and explore to explore fields that were unfamiliar yet interesting to me like organic chemistry and computational physics through the courses in the first tiers and doing so alongside other like-minded students was another reason to take part.

The abstract of my research study

Morphological characteristics of neurons, such as spine shape and dendrite branching, are crucial to understand the functional properties of neurons and cognition in neurodegenerative disorders. However, current tools for automated neuronal morphological analysis are mostly unsuitable for simple light microscopic images. Limitations by manual analysis methods leaves crucial relationships between neuronal morphology and function in the dark. Common analysis techniques used today, such as Sholl Analysis and eye-balling spine classification, also pose restrictions on revealing these relationships. Here, we explore the use of RECONSTRUCT for analysing spine morphology and investigate how a better method of spine classification can be achieved. We also discuss the use of Simple Neurite Tracer to study dendrite arborisation complexity with greater flexibility on analysis work. Together our results can optimise the analysis workflow in neuroscience research and help reveal insightful observations from microscopic images.

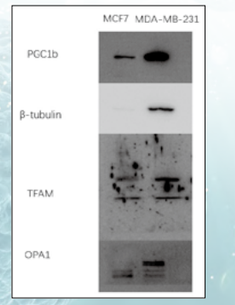
LIFE SCIENCES

Stem cell research and cancer research

FONG Tsz Lun
School: Tsuen Wan Government Secondary School
Project Leader: Professor TSANG Suk Ying Faye

The reasons that I join the programme

I am always interested in different aspects of science. There is a lot more to learn besides knowledge in textbooks. This programme offers me an opportunity to study various science subjects more in-depth while providing a wide range of related topics to choose from. In addition, the advanced level of knowledge and experimental methods to be taught in this programme are very attractive. It would be an extraordinary learning experience during my six years of secondary school life. Moreover, I hope the practical skills and first-hand experience acquired in the programme can benefit and pave the way for my future studies and career.



The abstract of my research study

Background: Cancer is one of the leading causes of death worldwide. Breast cancer is the most common cancer among females in Hong Kong and the third leading cause of cancer deaths among females in Hong Kong. It accounted for 27.2% of all new cancers in females diagnosed in Hong Kong in 2018. Mitochondria, being the powerhouse of the cell, could contribute to the maintenance of breast cancer properties, including proliferation, invasiveness, and resistance to therapy.

Aim: To investigate if mitochondrial biogenesis and dynamics are correlated to the maintenance of breast cancer properties.

Methods: The research was conducted with the use of online databases together with laboratory Western Blot sessions. The Human Protein Website was used to search for the prognosis data for potential mitochondrial genes correlated to breast cancer. The mutations of the genes were then searched in The Cancer Genome Atlas (TCGA). If the majority of cases were found to be related to the increased expression of a particular gene, Western Blot would be conducted to verify the original hypothesis.

Results: 11 genes were found to be poor prognostic markers of breast cancer. Within these 11 potential genes, DRP1, MFN1, OPA1, POLG, POLG2, and TFAM were found to have an elevated copy number in most of the cases reported in TCGA. Preliminary data by Western Blotting showed that both TFAM and OPA1 were upregulated in the more aggressive breast cancer cell line MDA-MB-231 when compared with the less aggressive cell line MCF-7. However, more experiments have to be conducted to further validate the findings.

Conclusion: In this research, it is concluded that an increased expression in some mitochondrial genes has a positive correlation with breast cancer. It could be possible that mitochondrial biogenesis and dynamics contribute to the aggressiveness of cancer cells.

CHEMISTRY

Pharmaceutical, agrochemical and material applications

HO Cheuk Yan Grace
School: St. Stephen's Girls College
Project Leader: Professor TSUI Chit Gavin

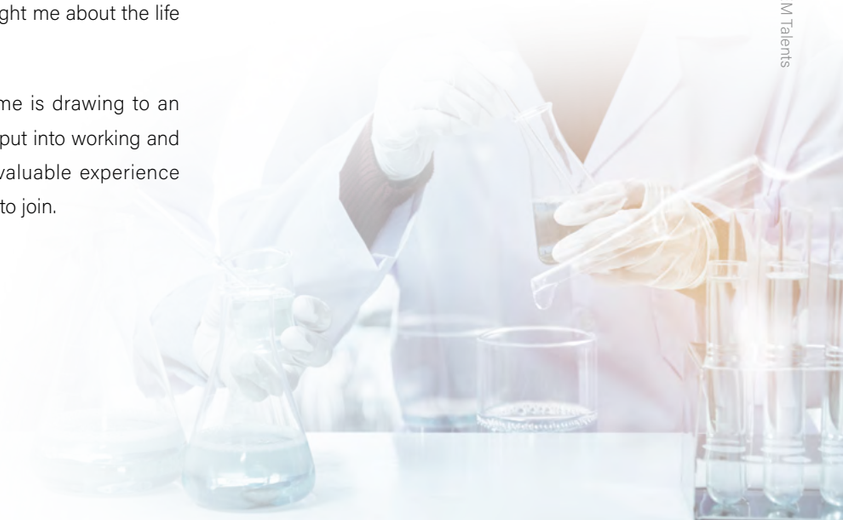
The reasons that I join the programme

I have always been intrigued by the prospect of conducting research in a laboratory. Once I heard that students entering Tier III of the programme would be given a chance to work in a university lab, I immediately signed up. My expectations were met and well exceeded. I was able to learn to use various apparatus and chemicals inaccessible in secondary school, including micropipettes, NMR spectrometers, columns for flash chromatography, solvents, volatile and explosive chemicals and more. My mentor taught me about the life of a PhD student.

Now that my time in the programme is drawing to an end, I do not regret the many hours put into working and studying in the laboratory. The invaluable experience alone is enough to convince anyone to join.

The abstract of my research study

Selective transformation of a single C-F bond of *gem*-difluoroalkenes is a powerful method for synthesizing stereodefined monofluoroalkenes. Monofluoroalkenes are important fluorinated molecules, as they have the potential to act as amide bond isosteres and enol mimics. As a result, a robust transition-metal-free transformation of *gem*-difluoroalkenes with aryl, primary, secondary, and tertiary alkyl Grignard reagents has been developed. The reaction is performed under mild conditions (room temperature) and leads to various monofluoroalkenes in good yields with excellent E stereoselectivity.



LIFE SCIENCES

Investigation on the effects of Trimethylamine N-oxide (TMAO) on vascular function

HO Sing Him
School: La Salle College
Project Leader: Professor WONG Wing Tak Jack

The reasons that I join the programme

My enthusiasm in science always drives me to broaden my knowledge beyond the school curriculum. In this STEM training programme, I had the opportunity not only to learn and apply scientific knowledge and lab techniques, but also to gain precious hands-on research experience from planning to carrying out the experiments. This exhausting yet fruitful experience has sparked my interest in research and enlightened myself to explore such intriguing topics in the future.

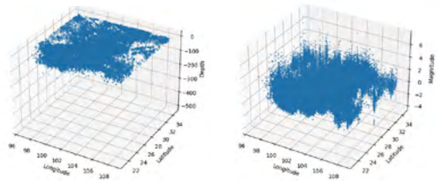
The abstract of my research study

Objectives: Trimethylamine N-Oxide (TMAO), a choline-derived gut microbiota metabolite, is linked with increased risk for cardiovascular disease. In this project, I hypothesize that TMAO induces endoplasmic reticulum stress, which promotes metabolic dysfunction in blood vessel endothelial cells. Methodology: C57BL/6J male mice were divided into 3 groups and fed with TMAO, its precursor trimethylamine (TMA) and PBS as control for two weeks. Aorta samples were collected and myography was used to examined the vascular reactivity in the aortic rings. The expression of several endoplasmic reticulum stress markers, including PKR-like endoplasmic reticulum kinase (PERK), activating transcription factor 6 (ATF6), inositol-requiring 1 (IRE1), Forkhead box protein O1 (FoxO1) mRNA and protein in aorta samples were examined using quantitative real-time polymerase chain reaction and Western blotting respectively. Results: My myograph results indicate that aortic rings from the TMAO group shows impairment in the acetylcholine-induced endothelium dependent relaxation compared to the control group. I am going to detect the levels of PERK and FoxO1 mRNA and protein expression in aortas from the TMAO group than in the control group. Conclusion: My results suggest a likely mechanism for TMAO-induced cardiometabolic diseases.

EARTH SYSTEM SCIENCE

Analysing potential precursory activity preceding large earthquakes

JOK Ronnie
School: St. Paul's Co-educational College
Project Leader: Prof. TAN Yen Joe

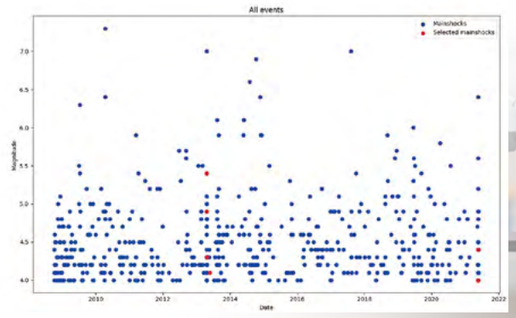


The reasons that I join the programme

I have always been fascinated by different branches of sciences and have actively sought programmes that allowed me to deepen my knowledge in the field of study. When I came across this programme on my school's intranet, my attention was immediately drawn to it, as the programme allows me to have a taste of science education at the tertiary level, and I will even be able to conduct research under the supervision of a professor. Another major attraction of the programme is the wide range of subjects it allows me to pursue, particularly life sciences and earth system science. These subjects are not available in secondary school, and although they are similar to biology and geography respectively, they are not exact equivalents. This exploration of new branches of science further encouraged me to apply to the programme.

The abstract of my research study

An earthquake is the vibration of the Earth due to a sudden release of energy in the subsurface that generates seismic waves. Large-magnitude earthquakes, although relatively rare, are rather destructive, often causing casualties and loss of property, and catastrophic events such as the 2004 Indian Ocean earthquake and 2011 Tōhoku earthquake can trigger other natural disasters (tsunamis in these two cases), causing huge amounts of damage and loss of life (the former caused an estimated 227,989 deaths in 14 countries, while the latter caused the Fukushima Daiichi nuclear disaster). Therefore, it has always been of great interest whether there are ways to accurately predict the occurrence of earthquakes. One of such methods under investigation is whether foreshocks, which are small earthquakes that sometimes occur preceding large earthquakes, can foretell an impending mainshock. Using a list of earthquakes in Mainland China as the dataset, this project aims to investigate the proportion of large earthquakes that have a significant foreshock activity, the correlation between foreshock activity and the mainshock properties, and the pattern of build-up of foreshocks. If a correlation between foreshock activity and mainshocks, and a pattern of foreshock build-up are found, we may use new measurements of seismic activity to forecast whether a large earthquake is impending, by comparing the seismic activity recorded to the typical background seismic activity.



LIFE SCIENCES

Stem cell research and cancer research

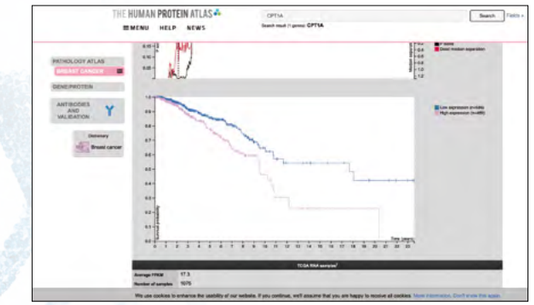
KWOK Man Yu Kelly
School: Marymount Secondary School
Project Leader: Professor TSANG Suk Ying Faye

The reasons that I join the programme

I joined the programme hoping to learn something outside of my high school curriculum. It serves as a means for me to understand myself better and to identify my field of interest. The research mentorship portion of the training programme is especially attractive as I have had no prior experience in scientific research beforehand. It allows me to understand the story behind the discovery of new knowledge and to learn under great minds in frontier research. I was also excited to learn about laboratory techniques throughout the programme. All these opportunities allow me to have a taste of what scientific research is and whether I am suitable for it.

The abstract of my research study

Breast cancer is the most common type of cancer in female in the world, yet there are few effective treatments for aggressive breast cancers such as triple-negative breast cancers (TNBC). Increased fatty acid oxidation activity has been shown to promote cancer cell survival. In this study, we looked at genes related to fatty acid oxidation in mitochondria and peroxisomes, as well as cancer stem cell markers, and tried to identify if those genes are associated to poor prognosis in patients. We studied survival plots on The Human Protein Atlas to determine the relationship between gene expression and prognosis. Among those genes, CPT1A caught our attention as its high expression corresponds to a significance decrease in survival probability in patients, especially in later years. To further investigate whether aggressive breast cancer cells have higher CPT1A expression, we performed Western blot on ER+/PR+ line MCF-7 and TNBC line MDA-MB-231 respectively. As the housekeeping protein is not detected, further experiment has to be conducted using another housekeeping protein as loading control. If MDA-MB-231 does show a significantly higher expression level of CPT1A in a successful Western blot, it may imply that CPT1A may be a potential therapeutic target.



Mathematics

Representation theory

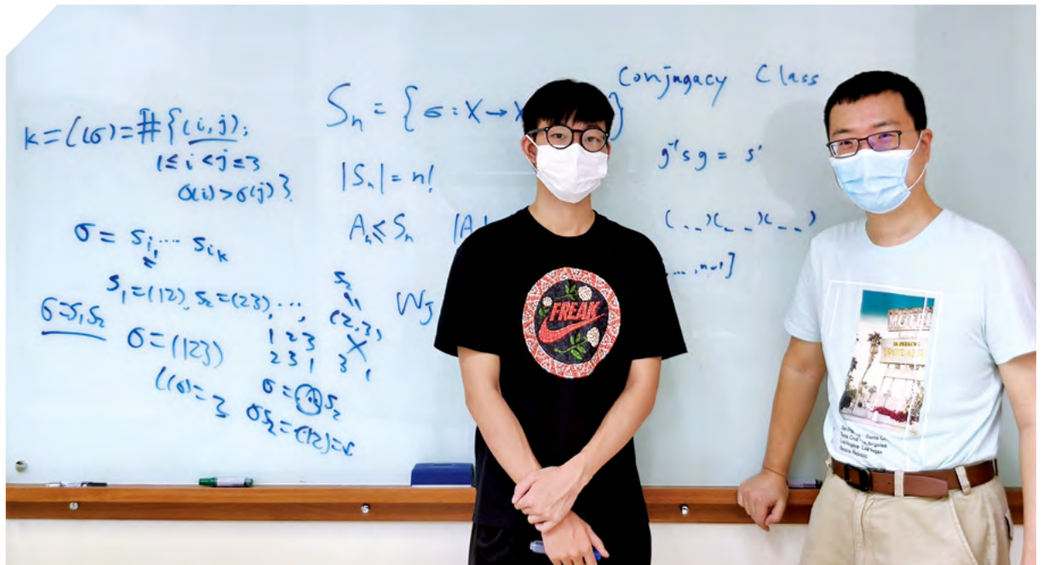
LI Tsz Shing
School: Kwun Tong Maryknoll College
Project Leader: Professor HE Xuhua

The reasons that I join the programme

I am interested in science and mathematics since I was young. So, I decided to take this chance to learn more about them. Although I have no idea what number theory is before I joined this programme, I was attracted by this interesting topic. On top of that, this programme started in summer vacation and is free of charge, so I apply for this programme without hesitation.

The abstract of my research study

Symmetric group S_n is important to areas of mathematic like representation theory, combinatorics and algebraic geometry. I investigated the Bruhat order of the symmetric group and it's set of cosets, which is closely related to the length function. The main objective of this research is to find out some explicit examples of the pair of permutations in a set of cosets such that they are closed under the Bruhat order. Before that, I have found out a description of the set of cosets which is done by focusing on the S_4 first and then generalized the patterns I have observed in the S_4. to any other symmetric group. The reason why I focus on S_4 is that it has total 24 elements so that the calculation on the cosets is not too trivial nor too complicated. Apart from the main result of this research, the method of calculating the coset and the Bruhat order is also demonstrated on the foam broad.



PHYSICS

Plasmon-enhanced nitrogen photofixation

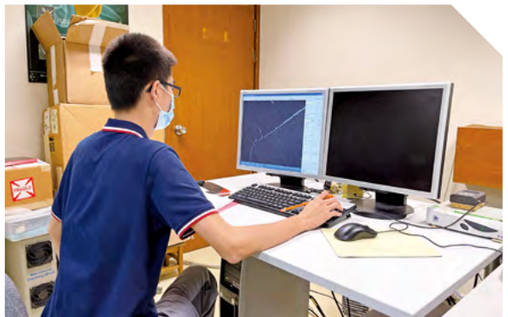
LO Kai Shun John

School: St. Paul's Co-educational College

Project Leader: Professor WANG Jianfang

The reasons that I join the programme

The major reasons why I join the programme are to deepen my understanding in science and gain hands-on experience in conducting scientific research. During the tier I and II programmes, I have a glimpse on science subjects such as physics, chemistry and biology at university level. The lectures have also equipped me with the necessary mathematical and research skills for me to excel in studying science. Through the tier III programme, during which I have researched on photofixation, I have acquired laboratory skills and understand more about the process of carrying out scientific research. In brief, the programme was a fruitful experience for me to delve into physics and deepen my interest.



The abstract of my research study

During the tier III programme, I have researched on nitrogen photofixation using molybdenum trioxide microspheres. I have prepared iron-doped and non-iron-doped molybdenum trioxide microspheres by aerosol spraying. The structure and constituents of microspheres were then analysed with a scanning electron microscope and EDX spectrum. The microspheres were immersed in water where nitrogen gas would pass through. Absorbing light energy from a xenon lamp, electrons of molybdenum trioxide were raised from the valence band to the conduction band. Oxygen vacancies on the surface of molybdenum trioxide trapped excited electrons and nitrogen molecules so that the trapped electrons reduced nitrogen with hydrogen from water to form ammonia. Every twenty minutes, one millilitre of the reaction mixture was extracted and Nessler's reagent, which would react with ammonia to form yellow sediments, was added to the mixture. The efficiency of the reaction was estimated by comparing the absorbance of the mixture at 436 nm to the standard curve. It was discovered that the catalytic efficiency of iron-doped molybdenum trioxide microspheres was higher than their non-iron-doped counterparts as doping iron increased the number of oxygen vacancies in molybdenum trioxide. Nitrogen photofixation may become an alternative for producing ammonia, which is currently manufactured through the energy-intensive Haber process. This can significantly reduce pollution and energy use stem from the manufacture of ammonia.

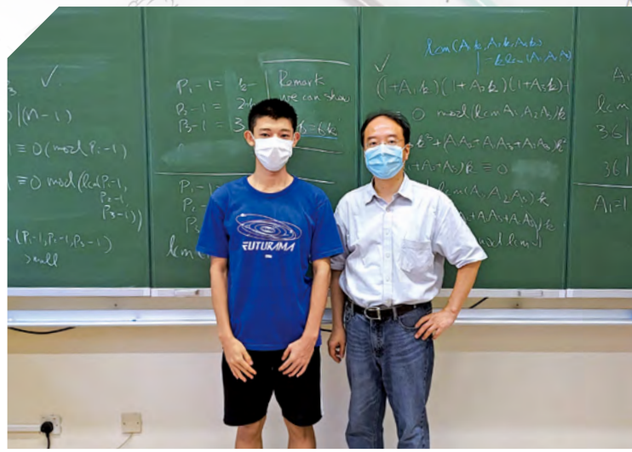
Mathematics

Topics in Primes with emphasis on the computational aspect

LUK Ka Chun

School: T.W.G.Hs Wong Fut Nam College

Project Leader: Dr. LI Chun Che Charles



The reasons that I join the programme

The main reason why I joined this programme is because I can gain a valuable learning experience. In this programme, I can enrich my knowledge on different subjects like mathematics, physics and statistics. The courses provided by this programme were taught by the professors in the Chinese University of Hong Kong and its level is near to University Year 1-2. It helps me to get better preparation in my university school life. What is more, this is a great opportunity to broaden my horizons since this programme provides six subjects for me to select. Some subjects like statistics and earth system science are not included in secondary school.

The abstract of my research study

My research topic is "Topic in primes with emphasis on the computational aspect". This topic is related to primality tests. The aim of this research is to find a relatively fast and accurate way to test whether a number is prime or not. My research focuses on three different primality tests, including Fermat's test, Miller's test and AKS test.

In the first part of the research, we focused on Fermat's test. We worked on some numerical examples in Fermat's test and showed that the existence of Carmichael numbers affects the accuracy of Fermat's test. Therefore, we have to find a more effective primality test. In the second part of the research, we focused on Miller's test. We showed that Miller's test is more accurate than Miller test since for any composite numbers n, there exists an integer a relatively prime to n such that n fails Miller's test to the base a. In the last part, we studied the AKS primality test, which is the first polynomial time primality test. We studied some numerical examples. Finally, we compared different primality tests.

LIFE SCIENCES

Cell Organelles Biogenesis and Functions

MA Ho Ming

School: La Salle College

Project Leader: Professor JIANG Liwen

The reasons that I join the programme

In the science education that I have received in the formal curriculum, facts are always emphasized over the process of scientific investigation and truth-seeking. Indeed, the question of how discoveries and findings were made is often neglected. That's why when the opportunity to study science with my hands arose in the form of the STEM Training Programme, I obviously did not hesitate to grasp it. My foundation can be consolidated by the advanced level lectures at the initial stages of the programme. Whereas I can finally take the initiative and formulate my own enquiry at tier three. By putting the prior skills and knowledge into practice, answering my own questions and clarifying misconceptions through a hands-on approach is now possible. This is a rewarding experience and is indeed a large part of why I wholeheartedly participated in the programme.

The abstract of my research study

Tip-vesicles (TVs) of growing pollen tubes

Pollen tube is one of the most well-studied tip-growing single cells in plants. The easy growth in vitro and the polar invasive fast-growing behavior make pollen tube an ideal tractable cell system to study intracellular vesicular trafficking.

Growing pollen tube tip is enriched with various populations of transport vesicles forming an inverted cone region called V-shape, which is gradually established during the early germination of the pollen grain and then sustains along the elongation of the pollen tube.

Our preliminary structural study by 2D transmission electron microscopy (TEM) analysis on germinating and growing tobacco pollen tube tips showed that, during early pollen germination stage when the inverted cone shape hasn't emerged, the tip-vesicles (TVs) is rather identical in morphology. However, upon later stage of rapid tube elongation, distinct populations of TVs with different size, shape and content can be observed, indicating that during the pollen germination and pollen tube elongation, different TVs with distinct functions have their own temporal specificity.

To resolve the diversification of TVs, we will take the resolution and volume advantages of whole-cell room-temperature electron tomography (ET) analysis with nanometer resolution and develop a high-resolution 3D developmental portrait of TVs 'dynamics' along the pollen tube emerging and elongation. This study will provide new insights about the nature of pollen tube TVs and their distinct functions in plants.

PHYSICS

Plasmon-enhanced nitrogen photofixation

TSANG Yi Tung

School: St. Mark's School

Project Leader: Professor WANG Jianfang

The reasons that I join the programme

Participating in the STEM training program has broadened my horizon and allowed me to have hands-on experience on how frontier researchers are working to progress in science. In the science subjects taught in secondary school, the curriculum focuses on teaching factual knowledge to provide us with essential understandings of science. Through joining this program, I discovered that a minute step in science often requires trials and errors, from constructing an experiment, recording data to tackling problems causing results that contradict the predictions. By standing on the shoulders of giants, not only can I see farther away, but it also allows me to realize the time and effort made by previous scientists to reach the current stage.

The abstract of my research study

The topic of my study is the plasmonic enhancement in nitrogen photofixation. Nitrogen-containing compounds, including ammonia, nitrate, are vital in organisms and our daily lives. However, it is hard to directly produce these compounds from atmospheric nitrogen due to the strong bonds between nitrogen atoms. Currently, there are three methods in synthesizing ammonia with atmospheric nitrogen, including lightning nitrogen fixation, biological nitrogen fixation, and the Haber-Bosch process. Nevertheless, lightning and biological nitrogen fixation are ineffective and inadequate when facing increasing demands. The Haber-Bosch process consumes about 1-2% of the world's energy output due to its high temperature (450 °C) and high pressure (250 atm). Recently, photocatalysis became a promising way of synthesizing ammonia because of its green and clean process in ambient conditions. With the development of studies on the localized surface plasmon resonance (LSPR), plasmonic photocatalysis has attracted much attention due to its plasmonic enhancement effects for improving the solar-chemical conversion efficiency (SCCE). MoO_{3-x}, a new type of plasmonic semiconductor with plenty of oxygen vacancies, is demonstrated for application in nitrogen photofixation. The oxygen vacancies serve as active sites for nitrogen gas adsorption and photocatalysis reaction. The aerosol sprayed MoO_{3-x} nanospheres show great potential in ammonia generation and promoting the SCCE.

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