FROM SPARKING CURIOSITY TO SUSTAINED INQUIRY

PLK Laws Foundation College

序一

羅焯生態實驗室於二〇一五年三月成立，想不到我捐助這生態實驗室的一小步，激發了更多同學在實驗室尋覓夢想，促成了保良局羅氏基金中學同學於科學研究邁出了一大步。由四位中四學生設計的「微重力狀態下雙擺運動的混沌性質」實驗繼於「香港中學生太空搭載實驗方案設計比賽」獲獎後，該實驗裝置更獲選於二〇一六年九月隨着神舟十一號飛船升空，送交天宮二號太空實驗室進行科研實驗。

過去兩年，學校積極發揮實驗室的優勢，先後與香港城市大學、香港科技大學合作，進行各種與生活息息相關的環境研究。師生亦身體力行，呼籲家人和朋友將生態保育融入日常生活中，成績有目共睹。

二〇一五年，同學搜集了一些家居和面部清潔產品，在實驗室中以過濾和蒸發的方法分析產品中的微膠粒含量，喚起同學對海洋微膠粒污染的關注，並於當年的里斯本國際青年會議上發表，獲大會選為優秀匯報之一。

二〇一六年，同學與香港科技大學環境學部合作，六個月內，每天量度空氣中的二氧化氮、臭氧、懸浮粒子濃度，繼而把數據與大氣狀況和能見度一併分析，找出當中的關聯。為搜集精準的數據，同學更利用實驗室的懸浮粒子監測儀同步進行取樣。此研究亦於同年舉行的丹麥國際青年會議上發表，提醒與會青年對空氣污染的關注。同學亦有意在來年重啟研究，並利用新添的二氧化硫監測儀，全面分析空氣質素。

本學年，同學再次與香港海洋公園保育基金和香港城市大學生物及化學系合作，於校內飼養瀕危海洋物種馬蹄蟹，並於明年夏季將牠們送歸大自然，期望喚醒社會對保育瀕危海洋物種的關注。學生把這保育經驗於二〇一七年七月在美國波特蘭的國際青年會議上發表。同學們能身體力行進行保育，實在令我欣喜。

中國現代數學之父和國際數學大師華羅庚認為：「科學的靈感，決不是坐著等待就可以等來的。如果說，科學上的發現有甚麼偶然的機遇的話，那麼這種偶然的機遇只能給那些學有素養的人，給那些善於獨立思考的人，給那些具有鍥而不捨的精神的人。」經歷、了解、欣賞、保育為關愛生態的「四步曲」。要達致前兩者不難，都是紙上談兵，把知識昇華至欣賞和保育卻有賴長時間的身體力行。我樂見學生實實在在地把科學應用在生活上，又把他們對生態的關愛傳承下去，期待日後有更多有趣的環境研究。

羅焯生態實驗室贊助人

羅焯

Foreword 2

The world we live in is full of mysteries and wonder. We can discover the whole world, preserve and develop it to the best living environment for mankind. Most improvements come from science and technologies developed by people with inquisitive minds. Therefore, we, as educators or parents, our job is to try our best to nurture our next generation to enable them to fully utilize their talents to beyond their imagination. This book is an excellent example of such immense inspiration created by the vision and passion of the founders and teachers of Po Leung Kuk Laws Foundation College.

Decades ago, after we landed the Moon, planted flags on every corner of the earth, from Everest to Ocean floors and the Poles, people started to question: "What's left to explore in our planet"? So scientists moved into outer space, landed the Mars. The Voyager 1 is now officially crossed our solar system travelling into the interstellar Space.

Within our planet, human travelling in space shall become a fact and perhaps affordable. We can now explore the Globe in absolute details with the Drones going where we cannot or afraid to go and enjoy in our own home. Nanodevice can be used to travel through our blood vessels as health inspector to achieve "preventive medicine" for each individual in the future.

In Biology, the speed and depth in discovering the mysteries of life is even more fascinating. It took Gregor Mendel 8 years to finish his genetic study in beans in 1860s to establish the basic laws of inheritance which were not recognized till 1908. I remember mapping the globin gene in two weeks was considered fast in National Institute of Health, USA and we were overjoyed when we successfully isolated the first thalassemia genomic clone that took a whole team a year from DNA human library we constructed in 1979. The human genome project took 15 years and US$3 billion to finish but now can be done in a few days for US$1000 and may soon be able to do in our own hands.

We can now virtually enjoy visiting anywhere, anyone around the globe and could travel near the speed of light. Replacing our organs and our defective genes to keep us healthy by regenerative technologies could be here soon. I have witnessed all these incredible achievements in my 40 years' professional life and all these were developed by people through their inquisitive mind and beyond their imagination.

The setup of the Biotechnology laboratory in 2006 by Principal Daniel W.K. Chan of Po Leung Kuk Laws Foundation College was an exception and indeed a pioneering example in Hong Kong Schools. DiagCor is fortunate and privileged to be part of this visionary mission. The current two Laboratories have been providing unique opportunities for students to explore in a wide variety of research areas as presented in this volume entitled "From sparking curiosity to sustained inquiry".

FOREWORD

This book documented the exceptional achievements of the past students; shared their experiences in the research process, their excitement in solving problems, their exchanges with international authorities and peers of different races that shaped their confidence and global perspectives in life and finally the joy of being recognized with Awards. Essays also covered research abstracts to share their project planning, their critical thinking process and research results that could have impact to our society.

This manuscript is a vivid demonstration of the impact and these extra-curricular activities to the participants have led to solid preparation on their personality and career future. I thoroughly enjoyed the reading and I sincerely hope the parents, friends and informed citizens will too. Finally, I like to congratulate Principal Daniel W.K. Chan and teachers involved for the excellent achievements. Their vision, dedication and passionate guidance to students all these years in sustaining the difficult operation are admirable. I hereby like to appeal to readers to give strong support in whatever capacity you can to help science flourish continuously.

Prof. Joseph Wing On TAM
The Sponsor of the
DiagCor Biotechnology Laboratory

Introduction

From sparking curiosity to sustained inquiry

Mr. CHAN Wing Kwong, Daniel, School Principal

"*I have no special talent. I am only passionately curious.*"
-Albert Einstein

"Curiosity killed the cat" is a proverb, by James Allan Mair's 1873 compendium a handbook of proverbs, used to warn of the dangers of unnecessary investigation or experimentation. Similar doubts were raised by early religious thinkers that Eve was banished from Eden, that Lot's wife who couldn't resist a peek to look back on the destruction of the cities of Sodom and Gomorrah, and was turned into a pillar of salt, may have been caused by improper and unrealistic curiosity. Borowske (2005: 346) argued that such connotation was thought to have been at least partially responsible for the view to equate curiosity with a lust for knowledge that only God had a right to possess.

Contrary to the 'religious skepticism' about curiosity, educators, since the last half of the twentieth century, generally recognized that curiosity is a significant motivating factor in student learning. James (1890) classified curiosity into two types. The first is an instinctual or emotional response, in which attention is aroused by finding something new. The other type of curiosity is the kind of "scientific curiosity" and "metaphysical wonder" in which the "brain responds to an inconsistency or a gap in its knowledge..." Berlyne (1954:3) later echoed by describing two types of curiosity: *Diversive* and *Specific*. Diversive curiosity is a general tendency for a person to seek novelty and search for adventure. Specific curiosity is a tendency to investigate a specific object or problem in order to understand it. Other researchers advocated that if the teacher can guide students towards the 'zone of curiosity' and the manageable knowledge gaps that complement the natural curiosity in a learner, combined with explicit connections to the learner's value system, sustained inquiry will then emerge and flourish (Day 1982; Loewenstein 1994).

Ever since this school was opened in 2004, Inquiry-based Learning has been adopted to facilitate students to learn how ideas can be transformed into formalized understanding and further questioning. Most importantly is the students' curiosity towards open-ended investigations into a question or a problem, requiring them to engage in evidence-based reasoning and creative problem-solving, as well as "problem finding." Underlying this approach is the idea that both teachers and students share the 'collective cognitive responsibility for the advancement of knowledge' (Scardamalia 2002). During the past decade, our students joining the Annual Meeting of Society for Neuroscience

(2006-2017), the Space Science Experiment Design Competition (2015), and the Youth Conference of Caretakers of the Environment International (2007-2017), play an important role throughout the process by establishing a culture where ideas are respectfully challenged and tested, moving students from a position of wondering to a position of enacting understanding and further questioning.

Strong et al. (1995) argues that students who are engaged in their work are energized by four goals – success (the need for mastery), curiosity (the need for understanding), originality (the need for self-expression), and satisfying relationships (the need for involvement with others). It is interesting to note that students will discover a different landscape when they are engaged in Inquiry-based Learning. In 2015, the four Year-10 students who joined the Space Science Experiment Design Competition, submitted their proposal, *Chaotic or Predictable? Oscillation of a Double Pendulum Under Weightlessness Condition*. They were attracted to the double pendulum's non-predictability of oscillation and would like to understand which theories govern the corresponding differences of such chaotic motion on the Earth and under a microgravity environment in the space laboratory. On constructing the experimental setup, they figured out that the duration of oscillation was not long enough for significant observation. In order to lengthen the oscillation time interval, they studied the applicability of different measures such as greasing the joints between moving parts, trying different materials such as iron, aluminum, wood and plastic to construct the pendulum. After collecting sufficient information, they decided to introduce mini-sized ball bearings to make the junctions smooth so that the duration of oscillation of the double-pendulum is greatly increased. In terms of the Mathematics regarding the double-pendulum, they searched for the scientific reference journals to discover that the decay of oscillation of a double pendulum is related to exponential decay function. Though they didn't understand the mathematics initially, they sought help from the teacher and understand its physical significance. It was their curiosity about the space project that motivated them to inquire further to the mathematical theories about the motion. Taking the advice from Ms. HUANG Wei-fen, Deputy Chief Designer, Astronaut Center of China that the two separate elastic punchers, giving initial velocities to the double pendulum, should be integrated to the double-pendulum as a single setup so as to facilitate being brought to the space, students were then engaged in drawing a series of diagrams to show the internal structure of the setup and discuss its feasibility with the experts. In modifying their setup, students showed patience and the determination to make the setup perfect. Teachers were very much impressed by their attitudes of rigor in conducting scientific experiments.

When the double pendulum was oscillating on the Earth, they found that the instantaneous tiny differences in positions of the two pendulums were difficult to be recorded. The students decided to use a high-speed camera to capture the slow motion of

the oscillation so that the motion of double pendulum at different instants can be investigated upon. This reveals that our students also paid attention to technological advancements. Evidence showed that inquiry learning enabled them to endure the challenges one by one to persist undergoing inquiry so as to reach the final destination.

Although ideas play such an important role throughout the inquiry process, it is the capability of observing minor changes in natural phenomena, persistence to find out the truth behind the observation and questioning the interrelationships between small pieces of evidence that pave the way for sustained inquiry. On the other hand, moving students beyond initial curiosity to a path of regular inquiry is one of the greatest challenges of inquiry-based learning. In this process, teachers play an important role. Teachers who modelled how to contribute and extend ideas, how to question and how to carry out an investigation of one's ideas or theories played the role of "provocateur," finding creative ways to introduce students to ideas and to subject matter that is of interest to them and offers "inquiry support" for students to engage in sustained inquiry of their own.

The beauty of this shared responsibility for learning practically grounded and nested in the landscape of Science, Technology, Engineering and Mathematics (STEM) naturally and beautifully. This 'collective cognitive responsibility for the advancement of knowledge' has cultivated a passion for deep learning inside and beyond the classroom by means of curiosity and passion, facilitating them to express their creativity through the cultivation of positive relationships among the students and the teachers. In promoting students' active participation in learning, what attributes will be most critical for our children to learn to become successful in their adult life? For me it's about passion, curiosity, imagination, critical thinking and grit.

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Inquiry-based Learning in Science Education

Dr. SUEN Ka Chun, Head, Board of Science

Science is a systematic study of the natural world by observation and experimentation (Foote 2007). Science inquiry is a way of thought by which human beings seek information and understanding of the natural world (Welch et al. 1981). According to Science for All Americans (AAAS, 1990), the teaching of science should be consistent with the nature of scientific inquiry while inquiry was not emphasized in science education until late 1950s and early 1960s (Chiappetta 1997). The National Science Education Standards (NRC, 1996) advocated that inquiry is central to learning science. Moreover, White and Frederikson (1998) indicated that inquiry-oriented curricula help make science accessible to both low-achieving and high-achieving students.

Inquiry-based learning and research-based learning have been proposed to promote students' learning. Below are some highlights of the intended objectives of inquiry-based and research-based learning:

"*Inquiry-based learning is a student-centered approach whereby students acquire the targeted competencies and learning outcomes through immersive open-ended experience.*" (Shaban et. al. 2015)

- "*Research-based learning incorporates critical thinking* (Nosich 2009) *and inquiry, and is an example of active and experiential learning.*" (Gail 2014)
- "*Research takes various forms, including primary research (e.g. collecting original data) and secondary research (e.g. collecting data from previous studies to learn about or address a research question). Primary research often begins with secondary research.*" (Gail 2014)"*The best way for students to learn research skills is to actually practice them, with guidance.*" (Kirschner et. al. 2006).
- "*Students acquire mindset of researchers: curiosity, critical thinking and reflection in research-based learning.*" (Jungmann 2011).
- "*Students experience, design and reflect a research process from the initial questions up to the presentation of results in research-based learning.*" (Jungmann 2011).

Biotechnology Curriculum

To nurture students' scientific literacy, creativity and curiosity, our school has developed a school-based biotechnology curriculum since 2004. It highlights bacterial, fungal, plant and animal cell culture, enriching the Integrated Science curriculum in junior forms. Different kinds of inquiry-based learning activities are introduced in S.1 – S.3 based on Renzulli's enrichment triad model (Renzulli 1976). A brief outline of our inquiry-based biotechnology curriculum is shown as follows:

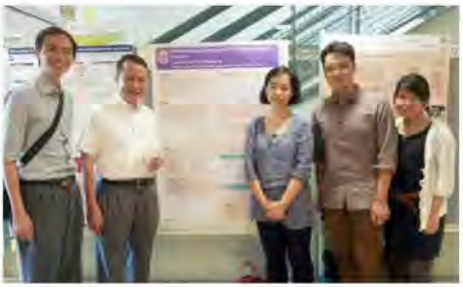
	S.1	S.2	S.3
Core topics	• Culture of microorganisms including bacteria and fungi • Application of cell culture to study bacterial and fungal growth	• Plant tissue culture • Animal cell culture • Application of cell culture to study cell growth and death	• DNA, RNA and proteins • Causes of cancer: concept of oncogene • Genetic modification: transformation of E. coli with green-fluorescent gene • Group-based research project
Inquiry-based learning tasks	Investigation on the effects of antibiotics and anti-bacterial agents; Investigation on the suitable conditions for fungal growth	Investigation on the responses of animal cells towards different types of stimuli and stresses	Investigation on the green-fluorescent proteins produced at different conditions

To share our experience in the development of the school-based biotechnology curriculum, our team of biotechnology teachers and school Principal were invited to present the topics titled "*The Development of a School-Based Science Curriculum (Biotechnology): Let us work together to make a difference*" in "iLongman - Integrated Science Seminar" on March 24, 2007 and "*Do we need to do something to our primary and junior secondary science curriculum?*" in "Learning for the Future" Series on January 10, 2009. In 2003, our science teachers also presented a conference paper titled "Effectiveness of the school-based Biotechnology curriculum – a science gifted programme for all" in the International Conference of East-Asian Association for Science Education.

Neuroscience Curriculum

To further nurture scientifically gifted students, our school has established a school-based neuroscience curriculum since 2005. We are a pioneer school in Hong Kong to develop a pull-out neuroscience curriculum based on the Purdue Three-Stage Enrichment Model. There are three stages in this model (Feldhusen and Kolloff 1986). Research-based learning emphasizing the development of students as independent researchers is adopted in our stage-3 neuroscience lessons (For details, please see p.60 of this book). To consolidate the development of our neuroscience curriculum, we have presented and published different papers about neuroscience education since 2007:

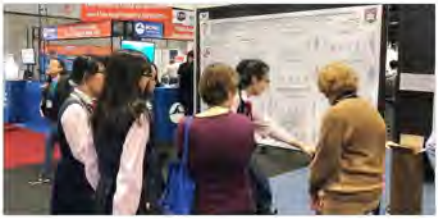
Year	Title
2007	Research-based learning associated with an authentic topic can promote active learning in high school neuroscience lessons
2008	Brain cell culture is an effective learning activity for high school students to acquire diverse knowledge and skills about neuroscience.
2010	Development of a school-based neuroscience curriculum in a high school in Hong Kong
2013	An example of a high school in Hong Kong to develop a school-based neuroscience curriculum as a pull-out program for scientifically gifted students
2013	A neuroscience pull-out gifted program in a high school in Hong Kong: Connection of neurodegenerative dis-eases and traditional Chinese medicine in research-based learning
2015	Evaluation of five learning activities associated with live-cell imaging microscopy in a high school neuroscience curriculum for scientifically gifted students
2017	Evaluation of a Pull-out Neuroscience Curriculum for High-school Gifted Students in Science



International Conference

In addition to the biotechnology and neuroscience curricula, our school has provided various learning opportunities for students to experience to be a scientist. Our students are encouraged to join international scientific conferences and present their research findings. In the conferences, students can experience how scientists exchange ideas and make constructive comments on others' research methods and findings. We have had six batches of students joining important conferences for scientists since 2006:

Conference	Year	Place	Research topic (published in the conference)
The 36th Annual Meeting of Society for Neuroscience	2006	Atlanta, GA, USA	Doing physical exercise has no indication on learning and memory enhancement in children aged 13-15; Increment of sleeping time does not implicate enhancement on memory and learning in adolescents.
The 38th Annual Meeting of Society for Neuroscience	2008	Washington DC, USA	Immediate night-time sleep helps memory consolidation in adolescents aged 13-14
The 40th Annual Meeting of Society for Neuroscience	2010	San Diego, CA, USA	Elicitation of a pungent sensation does not implicate memory modulation in adolescents aged 14-16
The 43th Annual Meeting of Society for Neuroscience	2013	San Diego, CA, USA	Dendrobium huoshanense can reduce hydrogen peroxide-induced toxicity in SH-SY5Y cells
The 45th Annual Meeting of Society for Neuroscience	2015	Chicago, IL, USA	Differential effects of seed extracts of citrus fruits against hydrogen peroxide-induced toxicity in SH-SY5Y cells
The 47th Annual Meeting of Society for Neuroscience	2017	Chicago, IL, USA	The individual and multiple effects of *Caulis Spatholobi*, *Salvia officinalis* and *Mentha citrata* in hydrogen peroxide-induced neurotoxicity



Our science teachers believe that science education in Po Leung Kuk Laws Foundation College can nurture students to be informed citizens and breed some of them to be future scientists. Through our enriched science curriculum, we hope that students will develop attitude to respect every life, appreciate the nature and make good use of their knowledge for helping people and protecting the environment.

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DiagCor Biotechnology Laboratory

In our first academic year 2004/2005, the school-based biotechnology curriculum was launched for our S.1 students. To support the practical lessons in biotechnology, our Biotechnology Laboratory equipped with cell culture facilities was established in January 2005. In order that our Biotechnology Laboratory can support more diverse types of advanced experiments in biotechnology like real-time PCR, DNA fingerprinting, large-scale plant tissue culture and microbial culture, the 2nd phase laboratory development was initiated in 2012. About HK$950,000 was utilized to purchase advanced-level equipment which can support research-based learning in biotechnology lessons and other programs such as neuroscience lessons. In 2015, our school received the generous support from DiagCor Bioscience Incorporation Limited and thus our Biotechnology Laboratory was further upgraded. A live-cell imaging system was installed to support research on cell biology. For example, students can study the real-time changes of different organelles under stresses induced by toxins, facilitating further investigation on drug discovery.

To recognize the generosity of DiagCor Bioscience Incorporation Limited, our biotechnology laboratory is named as DiagCor Biotechnology Laboratory. The Grand Opening of DiagCor Biotechnology Laboratory was officiated by Professor Yuk-Lam LO, Honorary Chairman of Hong Kong Biotechnology Organization and acknowledged by PLK Board of Directors 2014-2015 chaired by Ms. On-Kei LEONG on March 16, 2015.

Research on Drug Discovery

In our DiagCor Biotechnology Laboratory, there are cell culture facilities such as biological safety cabinets and microplate reader to support students to work on drug discovery research.

Below is the summary of the selected research projects about drug discovery done by our students. All of these projects had been submitted to different local or international competitions and scientific conferences for presentation. The full reports of the six projects (indicated by *) will be shown in the later part of this book.

Year	Research topic	Competition / Conference
2012/13	*Arisaema erubescens* cannot reduce cell death induced by oxidative stress in SH-SY5Y cell culture *	Hong Kong Youth Science & Technology Innovation Competition 2012-2013
2012/13	*Gentiana scabra*, a type of traditional Chinese medicine, cannot protect SH-SY5Y cells from oxidative stress *	Hong Kong Youth Science & Technology Innovation Competition 2012-2013
2012/13	Novel bio-detergent	Hong Kong Youth Science & Technology Innovation Competition 2012-2013
2012/13	*Angelica dahurica* cannot protect SH-SY5Y cells from hydrogen peroxide-induced toxicity	Roche Young Scientist Award 2012-2013
2012/13	*Alisma Orientalis* cannot reduce the cytotoxicity of H2O2	Roche Young Scientist Award 2012-2013
2013/14	中藥抗腦癌	二零一四年香港學生科學比賽
2014/15	The whole-seed extract of *Fortunella margarita* (Kumquat) reduces neuronal cell death induced by oxidative stress – Implication of the neuroprotective role of Fortunella margarita (Kumquat)'s seeds	Merit Prize in Hong Kong Youth Science & Technology Innovation Competition 2014-2015

2014/15	Can the extract of lemon's seed help against oxidative stress in neurodegeneration?	Merit Prize in Hong Kong Youth Science & Technology Innovation Competition 2014-2015
2014/15	*Dendrobium huoshanense*, a type of traditional Chinese Medicine can reduce hydrogen peroxide-induced toxicity in cultured SH-SY5Y cells	Merit Prize in Hong Kong Youth Science & Technology Innovation Competition 2014-2015
2015/16	金桔核提取物的腦神經保護作用*	第30屆全國青少年科技創新大賽 – 青少年科技創意項目「十佳科技創意之星」及「一等獎」
2015/16	2015/16霍山石斛對抗腦退化症的研究*	第30屆全國青少年科技創新大賽 – 青少年科技創意項目「三等獎」
2015/16	檸檬核提取物對抗過氧化氫的能力	第16屆“明天小小科學家”獎勵活動
2015/16	2015/16霍山石斛對抗腦退化症的研究*	第30屆全國青少年科技創新大賽 – 青少年科技創意項目「三等獎」
2015/16	檸檬核提取物對抗過氧化氫的能力	第16屆“明天小小科學家”獎勵活動
2015/16	黑豆和紅豆提取物的腦神經保護作用	第31屆全國青少年科技創新大賽
2015/16	Neuroprotective effects of mung beans, red beans, rice beans and black beans	Merit Prize in Hong Kong Youth Science & Technology Innovation Competition 2015-2016
2015/16	Differential effects of seed extracts of citrus fruits against hydrogen peroxide-induced toxicity in SH-SY5Y cells	Conference poster in the 45th Annual Meeting of Society for Neuroscience held in Chicago, IL, USA
2017/18	The individual and multiple effects of *Caulis Spatholobi, Salvia officinalis and Mentha citrata* in hydrogen peroxide-induced neurotoxicity	Conference poster in the 47th Annual Meeting of Society for Neuroscience held in Washington DC, USA

Student's Research Project

Arisaema erubescens cannot reduce cell death induced by oxidative stress in SH-SY5Y cell culture

CHUNG Ho Lim (S.4 in 2012/13), ABBASS Gary (S.2 in 2012/13) and HO Poon Kiu (S.3 in 2012/13)

Introduction

Alzheimer's disease and Parkinson's disease are neurodegenerative diseases (Emerit et al. 2004) and one of the suggested causes of these neurodegenerative diseases is believed to be induced by oxidative stress (Gorman et al., 1996). Hydrogen peroxide (H_2O_2) is often used to induce oxidative stress in cellular research (Wang et al. 2009). Hence, in the present study, H_2O_2 is chosen to induce cell death to imitate the situation of brain cells in the neurodegenerative diseases.

SH-SY5Y cells are a human cell line and commonly used in research of neurodegenerative diseases (http://en.wikipedia.org/wiki/SH-SY5Y). As our school has facilities to culture SH-SY5Y cells, we use this cell line as a model of neurodegenerative diseases when SH-SY5Y cells are treated with H_2O_2.

Arisaema erubescens (In Chinese, it is called 天南星) is a type of traditional Chinese Medicine. It contains paeonol (Ducki et al. 1995) and aurantiamide acetate (Ducki et al. 1996). It is believed that *Arisaema erubescens* contains paeonol which can reduce the superoxide in the brain (Hsieh et al. 2006).

The objective of the present study is to investigate whether *Arisaema erubescens* can help SH-SY5Y cells against cell death induced by H_2O_2.

Methodology

Source of *Arisaema erubescens*

The extract of *Arisaema Erubescens* was obtained from Dr. Raymond Chuen-Chung CHANG, Department of Anatomy, The University of Hong Kong. The powder form of this extract was then diluted with 0.6 ml of Dimethyl Sulphuroxide (DMSO) before use. The amount of DMSO finally added to cells was minimized as low as 0.01% in order to minimize the toxicity of DMSO.

Cell culture

SH-SY5Y cells were cultured in our school laboratory. The SH-SY5Y cell line was kept in DMEM with 10% of fetal bovine serum at 37°C and incubated with 5% carbon dioxide. The cells were seeded in 24-well plates for treatment. When the coverage of cells in the culture plate reached 70-80%, the cells were then used for the treatment with the extract of *Arisaema erubescens* and H_2O_2 separately.

Cytotoxicity test

The cytotoxicity of *Arisaema erubescens* was studied to look for non-toxic concentrations for the treatment with H_2O_2 later. Concentrations at 0.01μg/ml – 10,000μg/ml of *Arisaema erubescens were studied.*

Pre-treatment and treatment

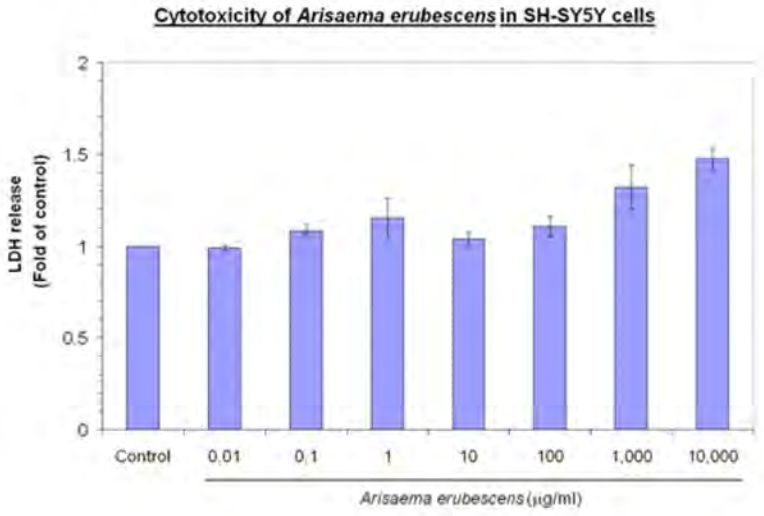
The SH-SY5Y cells were pre-treated with *Arisaema erubescens* at concentration of 0.01μg/ml – 100μg/ml in DMEM with 10% fetal bovine serum for 24 hours. Then, the cells were treated with H_2O_2 at 500μM or 750μM for the next 24 hours in 5% serum DMEM without *Arisaema erubescens*. All experiments were repeated three times.

Measurement of cell death

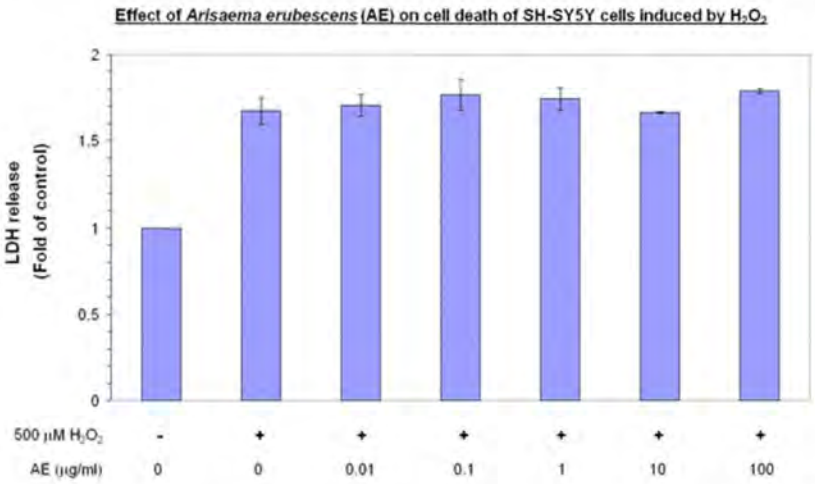
Lactate dehydrogenase (LDH) release assay was used to measure the cell death induced by H_2O_2. LDH release Assay was done by adding 50μl sample and 50μl LDH reagent into a well in the 96-well plate. This procedure was repeated three times with each well in the 24-well plate. The mixture was then incubated at room temperature for 30 minutes. The absorbance of the mixture was measured with our school's 96-well plate spectrophotometer at 492nm.

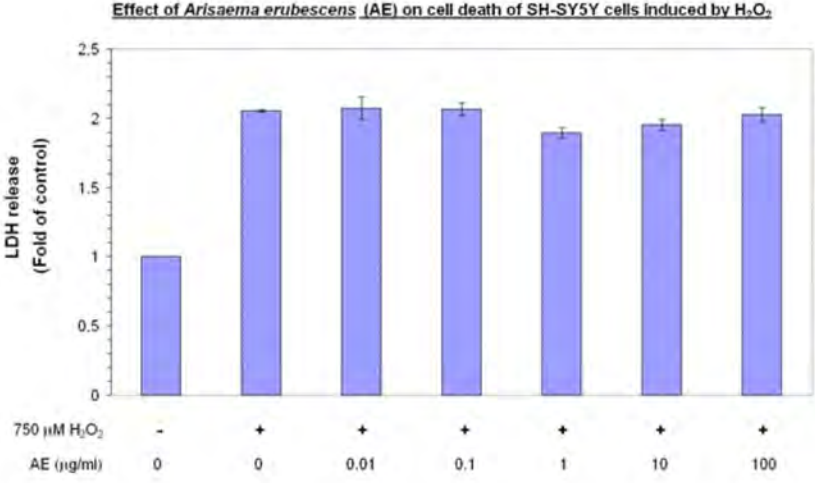
Results

There was no cytotoxicity of the concentrations of *Arisaema erubescens* at 0.01μg/ml – 100μg/ml. This was shown in the graph below:



Arisaema erubescens cannot protect H2O2-induced cell death in SH-SY5Y cells. This was shown by the graphs below:





Discussion and conclusion

The present study shows that the *Arisaema erubescens* extract cannot prevent or protect cell death when H_2O_2 is added in SH-SY5Y cells while other reports indicated that *Arisaema erubescens* consists of paeonol which is a chemical proposed to achieve protective effects. *Arisaema erubescens* cannot reduce cell death induced by oxidative stress in SH-SY5Y cell culture in our present study.

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Student's Research Project

Gentiana scabra, a type of traditional Chinese medicine, cannot protect SH-SY5Y cells from oxidative stress

HO Poon Kiu (S.3 in 2012/13), MA Ho Him (S.3 in 2012/13) and CHOW Pak Chun (S.3 in 2012/13)

Abstract

Neuronal death is found in neurodegenerative diseases including Alzheimer's disease and Parkinson's disease. It is believed that oxidative stress may play a role in the neurodegeneration. *Gentiana scabra* is a type of traditional Chinese medicine which is commonly used to treat hepatitis, stomatitis and inflammatory diseases. Recently, it is found that *Gentiana scabra* has effects on the central nervous system. The present study is to investigate whether *Gentiana scabra* can protect neuronal cells against oxidative stress. Our model of neurodegenerative diseases was made by culturing neuroblastoma cells (SH-SY5Y) which were treated with hydrogen peroxide (H_2O_2) at 500 microM or 750 microM. Neuroprotection of *Gentiana scabra* against H_2O_2 was measured by cellular release of lactate dehydrogenase (LDH) assay. Our results showed that pretreatment of *Gentiana scabra* at concentrations of 0, 0.01, 0.1, 1, 10 and 100 μg/ml cannot protect SH-SY5Y cells against H_2O_2-induced toxicity. This indicates that *Gentiana scabra* may not help neurons against oxidative stress in neurodegenerative diseases.

Introduction

Gentiana scabra (In Chinese, it is called 龍膽) is a type of traditional Chinese Medicine. It is used to treat hepatitis, stomatitis, and inflammatory diseases (Ho et al. 2011; Jiang and Xue 2005). This Chinese herb is also used to promote digestive secretions (http://en.wikipedia.org/wiki/Gentiana_scabra). There was an experiment showing that *Gentiana scabra* had excitatory effects on the central nervous system on mice (http://www.114zhongyao.com/doc-view-146.html) . It is interesting that high concentrations of *Gentiana scabra* can have narcotic effects on the central nervous system (http://www.114zhongyao.com/doc-view-146.html). As Gentiana sp. has effects on the central nervous system, the present study is going to investigate whether *Gentiana scabra* can help against cell death in the brain. If yes, *Gentiana scabra* may help patients with neurodegenerative diseases such as Alzheimer's disease and Parkinson's disease.

To study the effects of *Gentiana scabra*, a cellular model was used. SH-SY5Y is a common neuroblastoma cells used in research of neurodegenerative diseases in which

neuronal cell death was studied (Jiang and Xue 2005). It was reported that oxidative stress was one of the reasons for neuronal death (Gorman et al. 1996). In the present study, hydrogen peroxide (H_2O_2) is used to induce cell death of SH-SY5Y cells to mimic the neuronal death in the brain in the patients with a neurodegenerative disease.

Objective

Since *Gentiana sp.* is reported to have effects on the Central Nervous System as mentioned above, we are going to study whether *Gentiana scabra* can help protect neuronal cells from cell death induced by oxidative stress.

Methodology

Source of *Gentiana scabra*

This traditional Chinese medicine was a gift from an Associate Professor in The University of Hong Kong. It was in the form of powder after extraction.

Cell culture

SH-SY5Y cells were cultured in DMEM with 10% fetal bovine serum in a culture flask in a CO_2 incubator at 37°C in our school Biotechnology Laboratory. For treatment with Gentiana scabra, SH-SY5Y cells were seed on 24-well culture plate. After the cells had grown to about 70% coverage, they were pre-treated with *Gentiana scabra* and then treated with H_2O_2.

Cytotoxicity test of *Gentiana scabra*

To test whether *Gentiana scabra* is toxic to the cells, an experiment was carried out as follows: *Gentiana scabra* was added into culture wells in the total volume of 400 μl with the following concentrations (μg/ml) of *Gentiana scabra*: 0, 0.01, 0.1, 1, 10, 100, 1000 and 10000. Then, the concentrations of *Gentiana scabra* without cytotoxicity were used to pre-treat SH-SY5Y cells before H_2O_2 treatment.

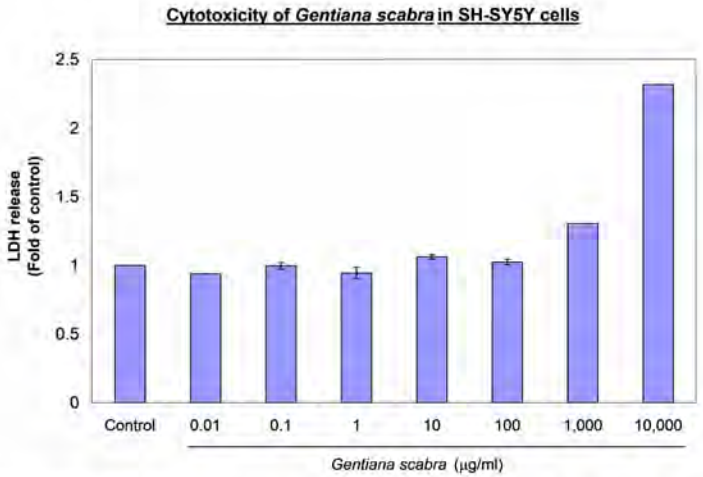
Pre-treatment and treatment

A total volume of 400 μl of *Gentiana scabra* at the concentrations of 0, 0.01, 0.1, 1, 10 and 100 μg/ml (these were the concentrations without cytotoxicity) was added to the SH-SY5Y cells for 24 hours. The Gentiana scabra was prepared in DMEM with 10% fetal bovine serum. After the pre-treatment for 2 hours, all medium with *Gentiana scabra* was removed. Concentrations of H_2O_2 at 500 μM and 750 μM were added to the cells for another 24 hours. All experiments were done in triplicate.

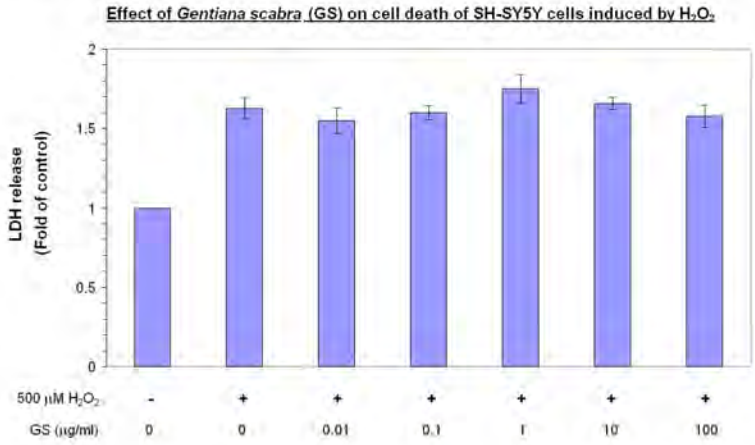
Measurement of cell death by LDH release assay

After the treatment for 24 hours, 50 µl of the solution from each well was transferred into a 96-well-plate. Then 50 µl of LDH assay reagent was added into the 96-well-plate. The mixture was then left at room temperature for 30 minutes. After that, absorbance of the LDH release assay was measured by a 96-well plate spectrophotometer at 492 nm. The results were then expressed as fold of control.

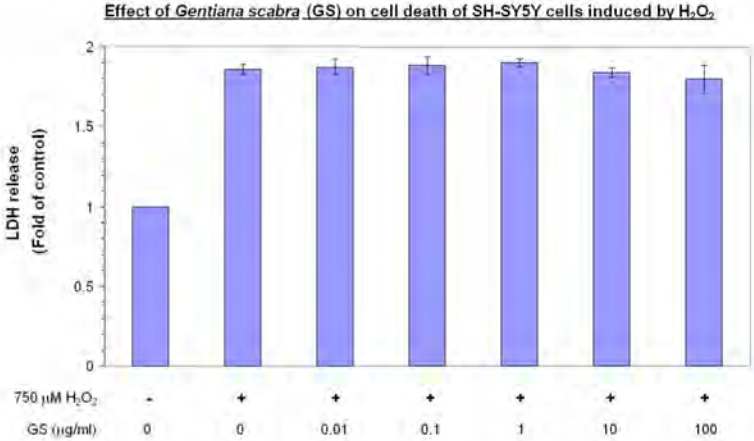
Results



According to the above graph, the *Gentiana scabra* at 1000 µg/ml and 10000 µg/ml was toxic to the cells and caused cell death showed by LDH release assay. So, we chose not to use these two concentrations to find out whether *Gentiana scabra* can help SH-SY5Y cells from the oxidantive diseases induced by H_2O_2.



The above diagram is the result of the effect of *Gentiana scabra* on cell death of SH-SY-5Y cells induced by H_2O_2. *Gentiana scabra* cannot signficantly help SH-SY5Y cells against H_2O_2 at 500 μM.



Discussion and conclusion

The above diagram is the result of the effect of *Gentiana scabra* on cell death of SH-SY-5Y cells induced by H_2O_2. *Gentiana scabra* cannot signficantly help SH-SY5Y cells against H_2O_2 at 750 μM.. In conclusion, *Gentiana scabra* cannot help SH-SY5Y cells against cell death from H_2O_2-induced cell death.

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學生研究作品

金桔核提取物的腦神經保護作用

周柏臻(2014/15年度中五學生)、洪英展(2014/15年度中五學生)

摘要

腦退化症的常見例子有老年癡呆症、柏金遜症，腦退化症的發生是由於腦細胞死亡，故有研究指出有抗氧化能力的物質可減少腦細胞死亡。金桔(學名：*Fortunella margarita*)，還未有科學家研究過金桔核的神經保護作用。鑒於現時大多數人在食金桔時都把核弄掉，可能浪費了金桔核的保護價值。因此這次研究目的是測試金桔核能否對因氧化壓力而死亡的腦細胞起保護作用。本研究使用腦細胞培植以模擬腦退化症的神經細胞死亡情況，結果顯示金桔核提取物能有效地減少因過氧化氫導致的細胞死亡，說明金桔核提取物有腦神經保護的功效。

引言

研究背景

現時仍未有有效治療腦退化症的方法，腦退化症的常見例子有老年癡呆症、柏金遜症，腦退化症的發生是由於腦細胞死亡(Emerit et al. 2004)。研究指出氧化壓力(Oxidative stress)是其中一種導致腦細胞死亡的原因(Gorman et al. 1996)，故有研究指出有抗氧化能力的物質可減少腦細胞死亡(Gray et al. 2015)。例如在一個柏金遜症研究，葡萄種子能對腦細胞提供保護作用(Strathearn et al. 2014)。

研究目的

雖然金桔(學名：*Fortunella margarita*)對我們的健康有好處如維持血管健康(http://baike.baidu.com/view/56747.htm)，但到目前為止，還未有科學家研究過金桔核的神經保護作用。鑒於現時大多數人在食金桔時都把核弄掉，可能浪費了金桔核的保護價值。因此這次研究目的是測試金桔核能否對因氧化壓力而死亡的腦細胞起保護作用。

研究方法

金桔核提取物

本研究所用的金桔是在香港新界將軍澳寶琳街市買，核從金桔中挖出，接著磨碎。磨碎的金桔核分別浸在兩種不同溶劑中，目的是以不同溶劑溶不同金桔核提取物。兩種溶劑分別是二甲基亞碸(Dimethyl sulfoxide，簡稱DMSO)和乙醇(ethanol)。磨碎了的金桔核在溶劑中搖勻一星期。之後離心機會把還未溶解的物質分離，浮在表層的液體會被收集和在0.22 μM過濾紙過濾，最後金桔核提取物存放在攝氏4度雪櫃。

細胞培植

本實驗用SH-SY5Y細胞，它是人類神經母細胞瘤（Human neuroblastoma），它常在腦退化症研究中使用(Cheung et al. 2009)。本研究用的SH-SY5Y細胞培植於已加入10%胎牛血清的Dulbecco's modified Eagle's medium（簡稱DMEM）培養液中，並於攝氏37度及5%二氧化碳的培植櫃中生長。本校有細胞培植儀器進行人類神經母細胞瘤培植。

引起SH-SY5Y死亡以模擬腦細胞死亡

由於過氧化氫(H_2O_2)常被用於為細胞提供氧化壓力，本次實驗亦以過氧化氫來模擬患有腦退化疾病的腦部細胞。500μM 過氧化氫（俗稱雙氧水）會用來引起SH-SY5Y細胞死亡，此濃度的過氧化氫也用於其他有關腦退化症的細胞培植研究。

測試金桔核提取物能否減少細胞死亡

待SH-SY5Y細胞生長覆蓋培養碟70%-80%，金桔核提取物（2500μg/ml，5000μg/ml和10000μg/ml）會加到SH-SY5Y細胞，混在2%胎牛血清的DMEM中。24小時後，取走金桔核提取物，加入500μM過氧化氫。24小時後，量度細胞死亡。

細胞死亡的測量－乳酸脫氫酶分析法

本實驗以乳酸脫氫酶測定法量度死胞死亡。乳酸脫氫酶測定試劑是從普洛麥格生物科技有限公司中購買。細胞死亡時，細胞膜破裂，細胞內的酶如乳酸脫氫酶會漏出細胞外。因此，量度在細胞外、培養液中的乳酸脫氫酶含量就能得出細胞死亡的相對數目。50μl的細胞培養液被混到50μl乳酸脫氫酶測定試劑中，並放置在暗處30分鐘。之後以分光光譜儀以492nm波長測量。

實驗的重複性及統計分析

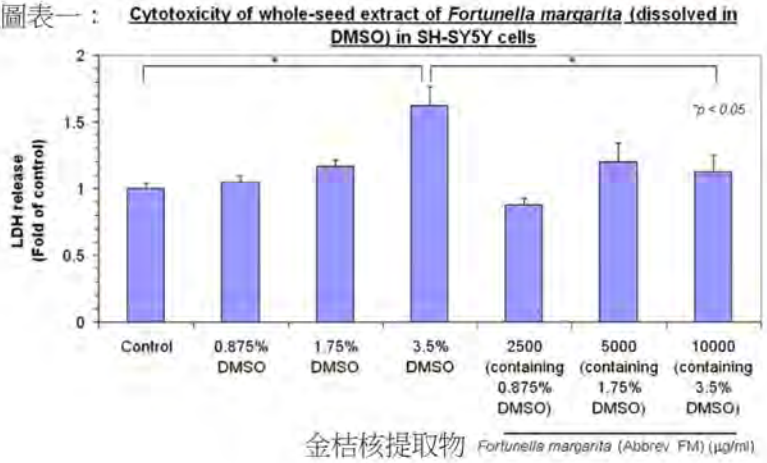
是次所有實驗均進行三次。統計分析採用單因數變異數分析及其事後多重比較。結果以標準誤差表達。

實驗結果

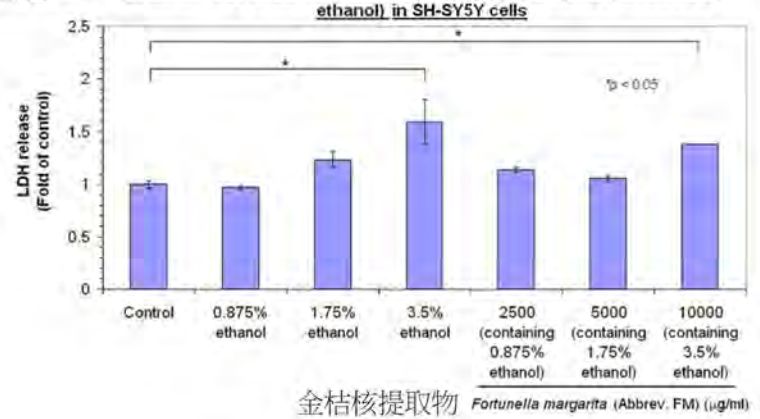
金桔核提取物對SH-SY5Y細胞的毒性

為瞭解金桔核提取物對SH-SY5Y細胞有沒有毒性，我們加不同濃度的金桔核提取物到SH-SY5Y細胞，24小時後量度培養液中的乳酸脫氫酶含量。另外，我們都測試兩種溶劑的毒性，因本實驗需使用很多溶液來溶金桔核粉。圖表一顯示3.5%二甲基亞碸對SH-SY5Y細胞有毒性，圖表二顯示3.5%乙醇對SH-SY5Y細胞也有毒性。另外，當金桔核提取物的濃度在10,000μg/ml時，金桔核提取物的毒性增加(圖表一及二)。

圖表一：



圖表二：

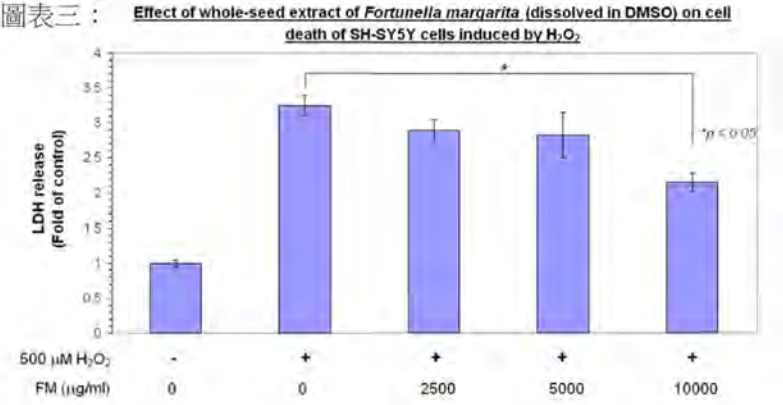


金桔核提取物對氧化壓力所引致的細胞死亡的影響

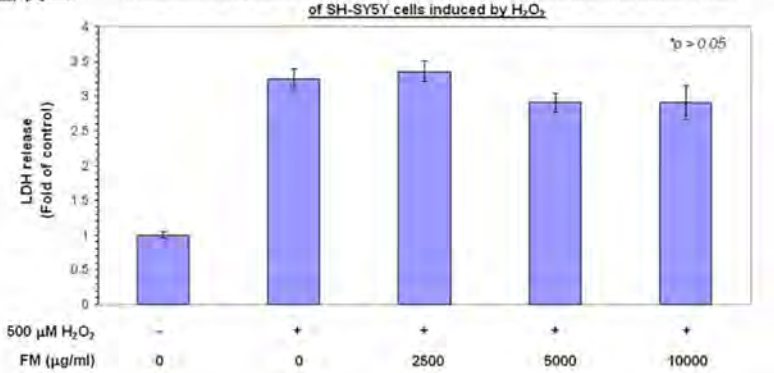
圖表三指出溶於二甲基亞碸的金桔核提取物在統計上能有效地減少因過氧化氫導致的細胞死亡。圖表四指出溶于乙醇的金桔核提取物似乎也能減低乳酸脫氫酶的漏出，但在統計學角度，細胞死亡率跟對照組沒有明顯的差距。

另外，圖表三和四顯示金桔核提取物中，似乎有相同成份的神經保護作用物質溶在二甲基亞碸和乙醇中，故我們估計金桔核提取物中之有效成份能溶於二甲基亞碸和乙醇中。

圖表三：



圖表四：



結論

由於金桔核提取物能有效地減少因過氧化氫導致的細胞死亡，說明金桔核提取物有腦神經保護的功效。當中的有效成份能溶於二甲基亞砜和乙醇中。

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學生研究作品

霍山石斛對抗腦退化症的研究

馬皓謙(2014/15年度中五學生)、鍾灝廉(2014/15年度中六學生)

摘要

霍山石斛是蘭科石斛屬的多年生草本植物，是中國國家瀕臨滅絕的珍貴藥材。雖然有文獻指出霍山石斛中的多糖有抗氧化能力，但科學家對它在對抗肝病、糖尿病、白內障的生物化學的運作機制仍未瞭解，故霍山石斛可能對其他疾病如腦退化症也有治療效果。腦退化症的發病原因是神經細胞死亡，根據科學研究，氧化壓力是其中一個原因引致神經細胞死亡，故減少氧化壓力可能是防止及治療腦退化症的一種方向。由於醫學界仍未有有效的方法去對抗及治療腦退化症，科學研究尋找有效的中草藥以減少神經細胞死亡是相當重要的。故本研究嘗試測試霍山石斛能否減少因氧化壓力引致的腦細胞死亡。本研究使用培植之人類神經母細胞瘤SH-SY5Y細胞及過氧化氫的毒性，來模擬腦退化症神經細胞之死亡。實驗結果顯示濃度10μg/ml的霍山石斛在統計上可減少因400μM過氧化氫造成的SH-SY5Y細胞死亡。本研究結果顯示霍山石斛可減少因氧化壓力引致的腦細胞死亡，說明霍山石斛可能可以用來預防和醫治腦退化症。

引言

霍山石斛之簡介

霍山石斛(學名：*Dendrobium huoshanense*)是蘭科石斛屬的多年生草本植物，主要產于大別山安徽霍山等地(http://baike.baidu.com/view/364900.htm、http://zh.wikipedia.org/wiki/霍山石斛、吳胡琦與羅建平，2009、吳胡琦與羅建平，2010)。它屬於中草藥材，是中國國家瀕臨滅絕的珍貴藥材(http://baike.baidu.com/view/364900.htm)。霍山石斛的藥用價值過往主要參考歷代本草中的記載，直至近年才有科學研究瞭解其藥理活性(吳胡琦與羅建平2009)。研究顯示霍山石斛可減少硒(Selenium)在老鼠引致的肝病及肝纖維變性(Pan et al. 2012)及能減少乙醇引致的肝傷害(Wang et al. 2014)，有動物研究指出霍山石斛可防止及醫治因糖尿病引起的白內障(Luo et al. 2008)，另有研究報告霍山石斛能有效降低血糖水準及清除自由基(free radical) (Lin 2003)，當老鼠長期服用霍山石斛，牠們免疫系統的功能如小腸的免疫細胞有所提升(Zha et al. 2014)。雖然有文獻指出霍山石斛中的多糖有抗氧化能力(Li et al. 2014；陳鳳芹等，2007)，但科學家對它在對抗肝病、糖尿病、白內障的生物化學的運作機制仍未瞭解(吳胡琦與羅建平，2010)，故霍山石斛可能對其他疾病也有治療效果。

腦退化症之簡介

老年癡呆症(Alzheimer's disease)、巴金森症(Parkinson's disease)和亨丁頓舞蹈症(Huntington's disease)是腦退化症的例子(Winner and Winkler 2015; Sutherland et al. 2013; Emerit et al. 2004)，它們的發病原因是神經細胞死亡(Winner and Winkler 2015; Sutherland et al. 2013; Emerit et al. 2004)。為何這些神經細胞會死亡？根據科學研究，相信其中一個原因是氧化壓力(Oxidative stress)引致神經細胞死亡(Sutherland et al. 2013; Emerit et al. 2004)。如果能減少氧化壓力，可能可以減少神經細胞的死亡，從而減輕患腦退化症病人的病況。故減少氧化壓力可能是防止及治療腦退化症的一種方向(Sutherland et al. 2013)。

研究目的

由於醫學界仍未有有效的方法去對抗及治療腦退化症，故科學研究尋找有效的中草藥以減少神經細胞死亡是相當重要的。因霍山石斛有抗氧化能力(Li et al. 2014；陳鳳芹等，2007)，故本研究嘗試測試霍山石斛能否減少因氧化壓力引致的腦細胞死亡。如果可以，霍山石斛則可以用來預防和醫治腦退化症。文獻顯示，暫時未有科學報告探討霍山石斛在腦退化症的功效，故本研究是第一份記錄有關霍山石斛在腦退化症的效能。

研究方法

霍山石斛之來源

本研究所用的霍山石斛是由香港大學李嘉誠醫學院解剖學系的腦神經退化症實驗室提供的。我們收到的霍山石斛是粉末狀態，之後這些粉末會溶於二甲基亞碸(Dimethyl sulfoxide，簡稱DMSO)，然後我們會使用0.22μm過濾膜過濾這些溶液以清除當中的微生物及不溶物質，最後霍山石斛溶液會存放於攝氏4度，並於3星期內用畢。為避免溶劑二甲基亞碸干擾細胞運作，影響實驗結果，本研究所使用的二甲基亞碸濃度少於0.01%，根據其它科學研究報告顯示，二甲基亞碸濃度到達1%才會傷害細胞，如破壞線粒體(Yuan et al. 2014)，另二甲基亞碸濃度到達4%對細胞可有保護作用(Banasik et al. 2004)，故本研究所使用的二甲基亞碸濃度不會引致細胞死亡，也不會提供保護作用。

腦細胞培植

本研究使用培植之腦細胞作測試工具以瞭解霍山石斛之神經保護作用。本研究所用的腦細胞是SH-SY5Y細胞，它是人類神經母細胞瘤(Human neuroblastoma)。因為這種細胞有普通腦細胞的特徵，故SH-SY5Y細胞常用於有關腦退化症的實驗(Cheung et al. 2009)。我們所使用的SH-SY5Y 細胞是由香港大學李嘉誠醫學院解剖學系的腦神經退化症實驗室提供的。SH-SY5Y細胞是於我們學校的生物科技實驗室裡培植，細胞培養液是Dulbecco's modified Eagle's medium(簡稱DMEM)，培養液中加入10%胎牛血清，細胞於

攝氏37度及5%二氧化碳的培植櫃中培植。

測試霍山石斛能否減少因氧化壓力引致的細胞死亡的步驟

首先，不同濃度的霍山石斛溶液會注入SH-SY5Y細胞的培養液(DMEM)裡，但同時我們會將胎牛血清的百分比由10%降至2%，因需要減少胎牛血清內未知物質對是次實驗的影響。我們實驗室很久前的實驗已證明當胎牛血清由10%降至2%是不會令SH-SY5Y細胞死亡。SH-SY5Y細胞在霍山石斛溶液裡24小時後，霍山石斛溶液會被抽走，然後400μM的過氧化氫(俗稱雙氧水)會注入，18小時後，我們便會測試有多少細胞是死亡的。因已有其它研究指出這濃度的過氧化氫能引致SH-SY5Y細胞死亡，故本研究使用400 μM的過氧化氫來引致SH-SY5Y細胞死亡，以模擬腦退化症中神經細胞因氧化壓力之死亡。

測試細胞死亡的方法－乳酸脫氫酶分析法

如上所述，SH-SY5Y細胞經過完18小時的過氧化氫處理後，我們會收集浸住細胞的細胞培養液。因當細胞死亡時細胞膜會破損，原本存在於細胞質內的乳酸脫氫酶(Lactate Dehydrogenase (簡稱LDH)會被釋放至細胞培養液中，當越多細胞死亡，便有越多乳酸脫氫酶被釋放至細胞培養液，借著乳酸脫氫酶分析法試劑(LDH Assay)及光譜儀，便可量度出乳酸脫氫酶的相對份量，以瞭解有幾多細胞死亡。

實驗的重複性及統計分析

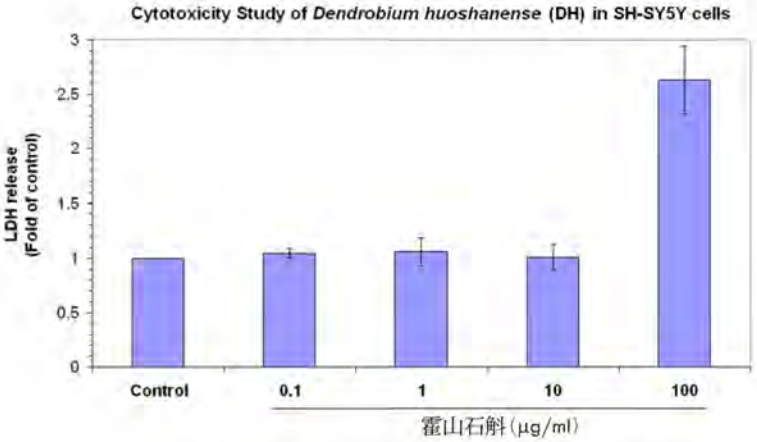
本研究所有實驗均進行三次或以上。統計分析則採用Daniel's XL Toolbox(下載網址：http://xltoolbox.sourceforge.net)的單因數變異數分析(One-way ANOVA)及其事後多重比較(Post-hoc test)。圖表資料結果則以標準誤差表達。

實驗結果

霍山石斛對SH-SY5Y細胞的毒性

我們先測試霍山石斛對SH-SY5Y細胞的毒性，因我們之後應使用沒有毒性的濃度，才可瞭解霍山石斛的神經保護作用。根據以下的圖表(表一)，濃度100μg/ml的霍山石斛會對SH-SY5Y細胞產生毒性，令細胞死亡。所以在以後的實驗裡，我們將不會採用100μg/ml或以上濃度的霍山石斛。我們之後便用0.1μg/ml, 1μg/ml 及10μg/ml濃度的霍山石斛，進行其它實驗。

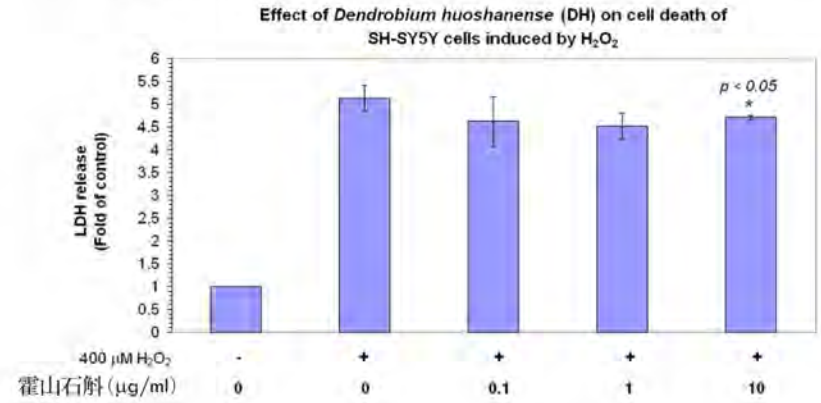
圖表一：霍山石斛對SH-SY5Y細胞的毒性



霍山石斛對氧化壓力所引至的細胞死亡的影響

濃度400μM的過氧化氫造成SH-SY5Y細胞死亡，細胞死亡幅度大約是對照組的5倍(圖表二：第一及第二組)。濃度10μg/ml的霍山石斛在統計上可減少因400μM過氧化氫造成的SH-SY5Y細胞死亡，乳酸脫氫酶的相對份量(與對照比較)大約由5倍降至4.5倍(圖表二：第二及第五組)。

圖表二：霍山石斛對氧化壓力所引至的細胞死亡的影響



結論

本研究結果顯示霍山石斛可減少因氧化壓力引致的腦細胞死亡，說明霍山石斛可能可以用來預防和醫治腦退化症。

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網頁：http://baike.baidu.com/view/364900.htm

網頁：http://zh.wikipedia.org/wiki/霍山石斛

Neuroscience Conference

From 2006 - 2017, six batches of our students joined an international scientific conference for neuroscientists in U.S.A. To acquire an eligibility to attend this conference, students are required to carry out a novel research and its findings have to be accepted by Society for Neuroscience, Washington DC, USA. In the conference, students will present their research findings and attend different lectures about neuroscience given by top neuroscientists. Below is the summary of our students participating in the Annual Meetings of Society for Neuroscience in 2006 – 2017.

Year	Students	Topic presented and Lecture attended
2006	Sum Chu Man (3S) Wong Chun Hei (3S) Sy Lok Him (3V) Chan Weng Hong (3V) Ho Hon Leung (3V) So Cheuk Yiu (3V) Ma Ka Him (3V)	Presentation: (1) Doing physical exercise has no indication on learning and memory enhancement in children aged 13-15 (2) Increment of sleeping time does not implicate enhancement on memory and learning in adolescents
2008	Yuen Chun Ting (3S) Wong Yat Hei (3N) Lam Ho Cheung (3M) Lo Chun Yin (3J) Li Lok Man (3V)	Presentation: Immediate night-time sleep helps memory consolidation in adolescents aged 13-14 Lectures: • What songbirds can teach us about learning and the brain anatomy and the problem of behavior • Sleep: studying a human behavior in an Insect
2010	Ho Ho Yin (4M) Wong Yat Hei (5M) Yuen Chun Ting (5J) Lam Ngo Hung (5J) Lau Sin Pang (5J)	Presentation: Elicitation of a pungent sensation does not implicate memory modulation in adolescents aged 14-16 Lectures: • Adventures in nontranslational research: neuronal differentiation and mechanosensory transduction in C. elegans • Dissection of the mouse brain: toward a 21st century brain pharmacology • Memory enhancement strategies for the treatment of cognitive disorders • The construction of memory circuits • Targeting protein phosphorylation to enhance memory • Genetic enhancement of memory in NR2B transgenic rats. • How Do I Smell? A Guided Tour of Human and Insect Olfaction

2013	Abbass Gary (3S) Chow Pak Chun (4J) Ma Ho Him (4J) Ho Poon Kiu (4V) Chung Ho Lim (5J)	Presentation: Dendrobium huoshanense can reduce hydrogen peroxide-induced toxicity in SH-SY5Y cells Lectures: • The mind of a worm: Learning from the C. elegans connectome • A molecular geneticist's approach to understanding the fly brain
2015	Hau Pak Chuen (5J) Shi Pok Lai (5J) Chau Wai Hin (5V) Chow Pak Chun (6J) Hung Ying Chin (6J) Ma Ho Him (6J)	Presentation: Differential effects of seed extracts of citrus fruits against hydrogen peroxide-induced toxicity in SH-SY5Y cells Lectures: • Themes and variations in circuits and behavior • A series of seminars about social fear learning, reward prediction and reinforcement, anxiety and learning, investment game on treatment of Parkinson's disease, autism and mental disorders • The molecular logic of neural circuits: implications for Autism and Schizophrenia • Strange synapses and circuits of the basal ganglia
2017	Hsu Tsun Ho (3V) Wong Suet Ming (4N) Cheung Yan Yuet (4J) Wan Ka Yu (4J) Chan Sau Tsun (4J) Wong Si Wing (4J) Wong King Chung (5M) Lee Ting Him (5S) Chau Cheuk Lam (5V) Law Chak Yan (6V) Tsui Wing Yin (6V) Cheung Coco Kit Yung (6V)	Presentation: The individual and multiple effects of Caulis Spatholobi, Salvia officinalis and Mentha citrata in hydrogen peroxide-induced neurotoxicity Lectures: • Insights from nonhuman animals Into the neurobiology of language • Using memory to guide decisions • Polymorphous polygenicity: The story of the genome in Schizophrenia • Cellular circadian clocks in the brains of helpless mice • Improving delivery of viral vectors to specific regions of the non-human primate brain • Neural correlates of an associative memory of elapsed time • Visual-verbal working memory training versus visual search training have overlapping and distinct transfer effects on tasks of spatial working memory and cognitive control: An event-related potential study • A novel mobile video game to assess the neural correlates of working and visual spatial memory for the brainstation wearable electroencephalography system

Neuroscience Conference and Students' Research in Neuroscience 2006

Doing physical exercise has no indication on learning and memory enhancement in children aged 13-15

Ka-Chun Suen[1], Hon-Leung Ho[1], Cheuk-Yiu So[1], Ka-Him Ma[1], Raymond Chuen-Chung Chang[2]

[1]Department of Science, Po Leung Kuk Laws Foundation College, Hong Kong

[2]Laboratory of Neurodegenerative Diseases, Department of Anatomy, Faculty of Medicine, The University of Hong Kong, Pokfulam, Hong Kong

Some studies have reported that doing physical exercise regularly has positive effects on neurocognitive and neuropsychological functions. Yet, few studies have indicated how doing physical exercise can enhance learning and memory in adolescents. The objective of the present study is to identify the effect of performing physical exercise on learning and memory in young school-learners. Our study was conducted in a secondary school in Hong Kong. Views about habits to do physical exercises from 97 students aged 13-15 were collected. The memory and learning ability of these students were assessed with Hong Kong List Learning Test (HKLLT) produced by Department of Psychology, The Chinese University of Hong Kong. The HKLLT is a modified version of the California Verbal Learning Test. Results showed that four groups of the students (total time to do physical exercise per day: <15, 15-30, >30-60 and >60 minutes) did not have significant differences in the learning slope, short and long recalls of the HKLLT. These results suggest that doing physical exercise has no significant effect or is not a key element on learning and memory enhancement in adolescents.

DOING PHYSICAL EXERCISE HAS NO INDICATION ON LEARNING AND MEMORY ENHANCEMENT IN CHILDREN AGED 13-15

K.C. SUEN[1], H.L. HO[1], C.Y. SO[1], K.H. MA[1], R.C.C. CHANG[2]

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SC Neuroscience Club

365.4/GG7

Introduction

Some studies have reported that doing physical exercise regularly has positive effects on neurocognitive and neuropsychological functions. Yet, few studies have indicated how doing physical exercise can enhance learning and memory in adolescents.

The objective of our study is to identify the effect of performing physical exercise on learning and memory in young school-learners.

Methodology

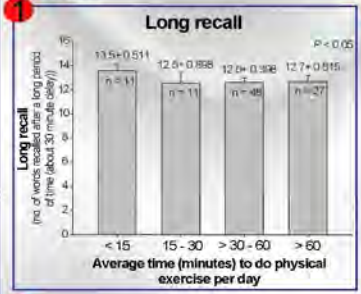
Our study was conducted in a secondary school in Hong Kong. Views about habits to do physical exercises from 97 students aged 13-15 were collected. The memory and learning ability of these students were assessed with Hong Kong List Learning Test (HKLLT) produced by Department of Psychology, The Chinese University of Hong Kong. The HKLLT is a modified version of the California Verbal Learning Test. There was a premise for this experiment: *the adolescents interviewed in this study received regular 1-hour physical education training every week and walk at least 30 minutes every day.*

Discussion

These results suggest that doing physical exercise has no significant effect or is not a key element on learning and memory enhancement in adolescents.

Results

1



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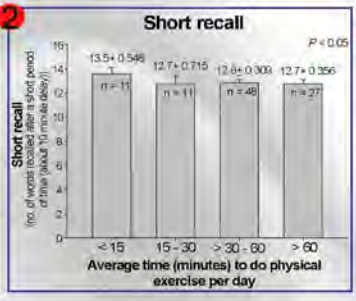

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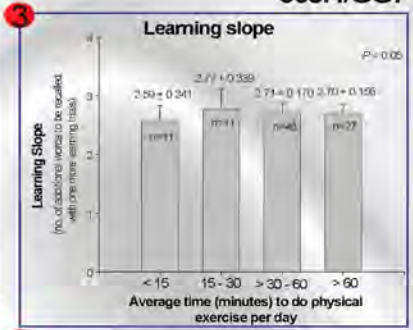

4 The results showed that four groups of the students (total time to do physical exercise per day: <15, 15-30, >30-60 and >60 minutes) did not have significant differences in the learning slope, short and long recalls of the HKLLT, with the premise that the interviewed students received regular 1-hour physical education training every week and walk at least 30 minutes every day.

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Student's Research Project: Poster Presentation in the 36th Annual Meeting of Society for Neuroscience in Atlanta, GA, USA in 2006

Increment of sleeping time does not implicate enhancement on memory and learning in adolescents

Michael Chu-Man Sum[1], Brian Lui[1], Lok-Him Sy[1], Weng-Hong Chan[1], Chun-Hei Wong[1], Ka-Chun Suen[1], *Raymond Chuen-Chung Chang[2]

[1]Department of Science, Po Leung Kuk Laws Foundation College, Hong Kong

[2]Laboratory of Neurodegenerative Diseases, Department of Anatomy, Faculty of Medicine, The University of Hong Kong, Pokfulam, Hong Kong

Sleep deprivation has been reported to decrease some cognitive performances. Adolescents are advised to sleep adequately in order to have better cognitive and physical development. Children aged 13-15 are suggested to achieve more than 8 or even 9 hours per day for sleep. Yet, nowadays, an increasing number of young people do not have sufficient sleeping time, which has been considered to affect their memory as well as learning effectiveness in daily schooling. To study the effect of sleeping hours on memory and learning performances, a hundred and three students aged 13-15 were interviewed about their sleeping habits. Their memory and learning ability were assessed with Hong Kong List Learning Test (HKLLT) produced by Department of Psychology, The Chinese University of Hong Kong. The HKLLT is a modified version of the California Verbal Learning Test. Our results showed that three groups of students (average daily sleeping hours: <6, 6-8 or >8) did not have significant differences in the learning slope, short and long recalls of the HKLLT. The results suggest that increment of sleeping hours does not show significant enhancement on memory and learning in adolescents.

Poster Presented in the 36th Annual Meeting of Society for Neuroscience in 2006

INCREMENT OF SLEEPING TIME DOES NOT IMPLICATE ENHANCEMENT ON MEMORY AND LEARNING IN ADOLESCENTS

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SC Neuroscience Club

365.3/GG6

Introduction

Sleep deprivation has been reported to decrease some cognitive performances. Adolescents are advised to sleep adequately in order to have better cognitive and physical development. Children aged 13-15 are suggested to achieve more than 8 or even 9 hours per day for sleep. Yet, nowadays, an increasing number of young people does not have sufficient sleeping time, which has been considered to affect their memory as well as learning effectiveness in daily schooling.

The objective of our study is to investigate the effect of insufficient sleeping hours on memory and learning performances in adolescents.

Methodology

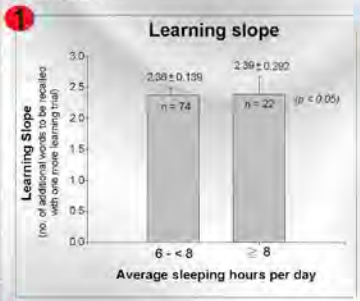
Our study was conducted in a secondary school in Hong Kong. One hundred students aged 13-15 were interviewed about their sleeping habits. Their memory and learning ability were assessed with Hong Kong List Learning Test (HKLLT) produced by Department of Psychology, The Chinese University of Hong Kong. The HKLLT is a modified version of the California Verbal Learning Test.

Discussion

The results suggest that increment of sleeping hours does not show significant enhancement on memory and learning in adolescents.

Results

1



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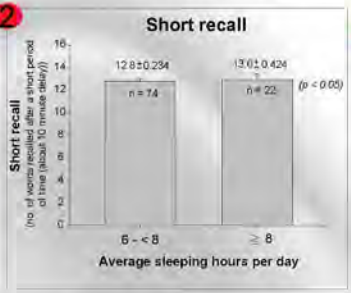

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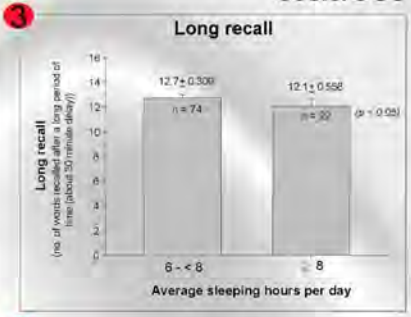

4

The results showed that two groups of students (average daily sleeping hours: 6 - <8 or ≥ 8) did not have significant differences in the learning slope, short and long recalls of the HKLLT.

Contact information

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Student's Research Project: Poster Presentation in the 38 th Annual Meeting of Society for Neuroscience in Washington DC, USA in 2008

Immediate night-time sleep helps memory consolidation in adolescents aged 13-14.

Ka-Chun Suen[1], Tsz-Wai Cheung[1], Lok-Man Li[1], Bernard Chun-Yin Lo[1], Ho-Cheung Lam[1], Yat-Hei Wong 1, Chun-Ting Yuen[1], Raymond Chuen-Chung Chang[2]

[1]Department of Science, Po Leung Kuk Laws Foundation College, Hong Kong

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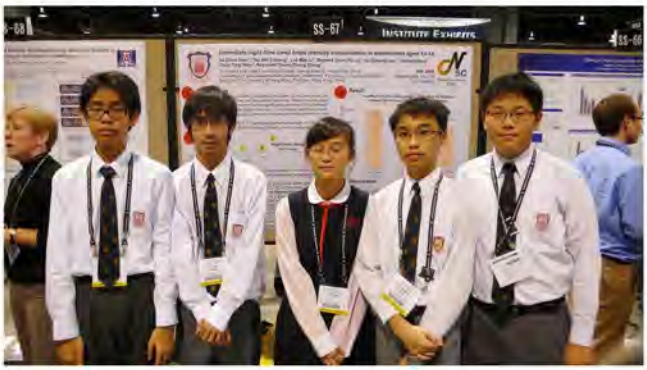
There is accumulating evidence suggesting that sleep is involved in the consolidation of both declarative and procedural memories. Recent studies indicate that memory performance can be significantly promoted if it is followed by sleep (even a short episode of day-time nap). Our previous report has shown that increment of sleep time at night does not implicate pre-enhancement on memory tasks in adolescents. To continue our study in the association of sleep and memory consolidation in adolescents, post-enhancement on memory consolidation by immediate night-time sleep following memory acquisition is investigated. A time course (5, 10 and 30 minutes) study showed that an immediate night-time sleep of either 5 minutes or 10 minutes shortly after a memory task helped memory consolidation in adolescents aged 13-14. A significant decrease in the post-enhancement on memory performance was found in the 30-minute experimental group. The present results implicate that the first 5-10 minutes shortly after the newly formation of short-term memory is a crucial period for memory consolidation in adolescents.



Poster Presented in the 38th Annual Meeting of Society for Neuroscience in 2008

Immediate night-time sleep helps memory consolidation in adolescents aged 13-14.

Ka-Chun Suen[1], Tsz-Wai Cheung[1], Lok-Man Li[1], Bernard Chun-Yin Lo[1], Ho-Cheung Lam[1], Yat-Hei Wong[1], Chun-Ting Yuen[1], Raymond Chuen-Chung Chang[2]

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SfN 2008, Washington, DC, US
587.5/SS67

Neuroscience Club

1 Introduction

There is accumulating evidence suggesting that sleep is involved in the consolidation of both declarative and procedural memories. Recent studies have indicated that memory performance can be significantly promoted if it is followed by sleep (even a short episode of day-time nap). Our previous report has shown that increment of sleep time at night does not implicate pre-enhancement on memory tasks in adolescents.

The objective of our study is to investigate post-enhancement on memory consolidation by immediate night-time sleep following memory acquisition.

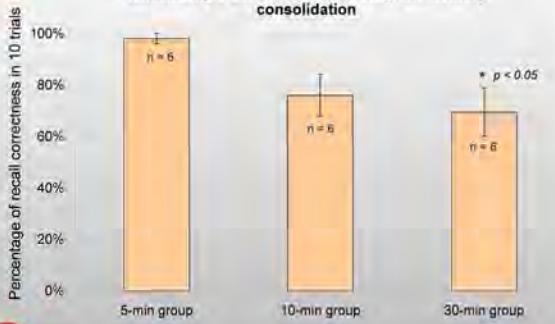
2 Methodology

a		x		b		c		d
Memory task					**Night-time sleep** (6-8 hours)		**Recall test**	
Memorize a set of 3 English letters or 3 Arabic numerals. t=?		*X = 5, 10 or 30 minutes*		*t=?*				

(1) Memory task (a): Adolescents aged 13-14 were asked to memorize a set 3 English letters or 3 Arabic numerals. The time for an adolescent to acquire the memory is not fixed.
(2) After the memory task, the adolescents were asked to do some other things which were not related to the memory task for 5, 10 or 30 minutes (x). ***The present study is to investigate the effect of X on memory consolidation.***
(3) The adolescents were then asked to sleep for 6-8 hours (b). Our previous study has shown that the amount of sleeping time (6-8 hours) has no significantly immediate effect on adolescents' learning and memory performance (Sum et. al. 2006).
(4) The participants may not fall asleep immediately after x. There may be a period of time (t) before the night-time sleep (c). Yet, this cannot be controlled and fixed in the present study.
(5) After (c), a recall test was conducted (d). If the set of English letters or Arabic numerals can be recalled, the recall correctness was then counted.

3 Result

The effect of a non-sleep period "*X*" (5, 10 or 30 minutes) followed by 6-8 hour night-time sleep on memory consolidation



4 Discussion

(1) A significant decrease in the post-enhancement on memory consolidation was found if x = 30 minutes.
(2) The present results implicate that the first 5-10 minutes shortly after the newly formation of short-term memory is a crucial period for memory consolidation in adolescents.

Contact information
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Student's Research Project: Poster Presentation in the 40th Annual Meeting of Society for Neuroscience in San Diego, CA, USA in 2010

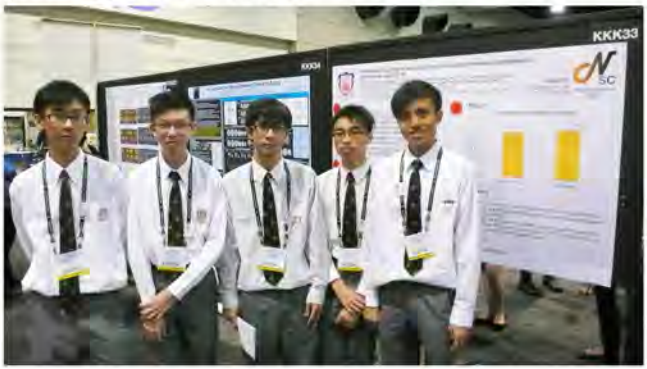
Elicitation of a pungent sensation does not implicate memory modulation in adolescents aged 14-16.

Ka-Chun Suen[1], Yat-Hei Wong[1], Chun-Ting Yuen[1], Ngo-Hung Lam[1], Ho-Yin Ho[1], Yuen-Tat Lau[1], Chi-Keung Cheng[1], Ho-Cheung Lam1, Dominic Hiu-Fung Tam[1], Sin-Pang Lau[1], Raymond Chuen-Chung Chang[2]

[1]Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, China

[2]Laboratory of Neurodegenerative Diseases, Department of Anatomy, LKS Faculty of Medicine, The University of Hong Kong, Pokfulam, Hong Kong, China

Pungent sensation induced by allyl isothiocyanate which is a functional ingredient in a Japanese horseradish called wasabi involves the activation of transient receptor potential ankyrin 1 (TRPA1). It has been suggested that TRPA1 is associated with cognitive impairment in Alzheimer's disease and neuroprotection on dentate gyrus granule cells. As our previous studies focus on daily-life strategies such as physical exercise and sleep for memory enhancement in adolescents, we further investigate whether elicitation of a pungent sensation would modulate memory recall. In the present study, children aged 14-16 spend 1 minute to orally taste wasabi to acquire a pungent sense, followed by an immediate 5-minute memory recall test displaying ten random combinations of three to four English alphabets plus one to two Arabic numbers in each attempt. Our results showed that the pungent sensation induced by wasabi showed no significant modulation on memory recall in the adolescents. This implicates that immediate elicitation of a pungent sensation in which TRPA1 may be involved does not help memory recall in adolescents.



Elicitation of a pungent sensation does not implicate memory modulation in adolescents aged 14-16.

Ka-Chun Suen[1], Yat-Hei Wong[1], Chun-Ting Yuen[1], Ngo-Hung Lam[1], Ho-Yin Ho[1], Yuen-Tat Lau[1], Chi-Keung Cheng[1], Ho-Cheung Lam[1], Dominic Hiu-Fung Tam[1], Sin-Pang Lau[1], Raymond Chuen-Chung Chang[2]

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SfN 2010,
San Diego, CA, US
701.12/KKK33

SC Neuroscience Club

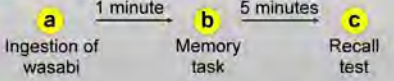
1 Introduction

Pungent sensation induced by allyl isothiocyanate which is a functional ingredient in a Japanese horseradish called wasabi involves the activation of transient receptor potential ankyrin 1 (TRPA1). It has been suggested that TRPA1 is associated with cognitive impairment in Alzheimer's disease and neuroprotection on dentate gyrus granule cells.

The objective of the present study is to investigate whether elicitation of a pungent sensation would modulate memory recall.

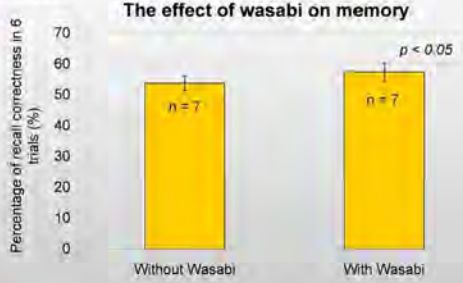
Our team focuses on the mechanism of memory modulation and the daily-life strategies such as doing physical exercise (in a previous study) for memory enhancement.

2 Methodology



- **a** Adolescents aged 14-16 tasted and then ingested 1/4 teaspoon of a commercially available wasabi to acquire a pungent sense.
- **b** The adolescents then did a 5-minute memory task in which they tried to memorize 10 random combinations consisting of 3-4 English alphabets plus 1-2 Arabic numbers (e.g. A4PG7; E2N8V).
- **c** Afterwards, the adolescents recalled the 10 sets of randomly combined alphabets and numbers.

3 Result



4 Discussion

(1) The present result indicates that oral administration of wasabi associated with elicitation of a pungent sensation has no significant modulation on immediate memory recall.
(2) As TRPA1 might be activated by wasabi which induces the pungent sensation immediately before the memory task, TRPA1 might not be involved in memory formation in the present study.

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Student's Research Project: Poster Presentation in the 43rd Annual Meeting of Society for Neuroscience in San Diego, CA, USA in 2013

Dendrobium huoshanense can reduce hydrogen peroxide-induced toxicity in SH-SY5Y cells.

Ka-Chun Suen [1], Ho-Lim Chung[1], Ho-Him Ma[1], Poon-Kiu Ho[1], Pak-Chun Chow[1], Theodore-Jeremy Tong[1], Gary Abbass[1], Cheuk-Yui Chung[1] and Raymond Chuen-Chung Chang[2]

[1]Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, China

[2]Laboratory of Neurodegenerative Diseases, Department of Anatomy, LKS Faculty of Medicine, The University of Hong Kong, Pokfulam, Hong Kong, China

Dendrobium huoshanense, an herb of Orchidaceae family, has long been used as traditional Chinese medicine for the protection of eye, stomach and liver. A recent study has shown that *Dendrobium huoshanense* can help prevent selenium-induced liver injury and fibrosis in rats. Moreover, this herb has been found to scavenge free oxygen radicals and inhibit nitric oxide generation, exerting antioxidative functions. In the present study, we aim to investigate the neuroprotective effects of *Dendrobium huoshanense* against oxidative stress which has been implicated in many neurological diseases such as ischemia, Alzheimer's disease and Parkinson's disease. Undifferentiated SH-SY5Y cells were pretreated with chemically extracted *Dendrobium huoshanense* for 24 hours. After removing *Dendrobium huoshanense* from the cells, they were treated with hydrogen peroxide for 18 hours. Results indicated that pretreatment of *Dendrobium huoshanense* can reduce the release of lactate dehydrogenase from SH-SY5Y cells in hydrogen peroxide-induced toxicity, implicating that *Dendrobium huoshanense* may help in neuroprotection.

Dendrobium huoshanense can reduce hydrogen peroxide-induced toxicity in SH-SY5Y cells.

Ka-Chun Suen[1], Ho-Lim Chung[1], Ho-Him Ma[1], Poon-Kiu Ho[1], Pak-Chun Chow[1], Theodore Jeremy Tong[1], Gary Abbass[1], Cheuk-Yui Chung[1], Raymond Chuen-Chung Chang[2]

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SfN 2013,
San Diego, CA, US
343.18/DD14

NSC Neuroscience Club

Introduction

Dendrobium huoshanense, an herb of Orchidaceae family, has long been used as traditional Chinese medicine for the protection of eye, stomach and liver. A recent study has shown that *Dendrobium huoshanense* can help prevent selenium-induced liver injury and fibrosis in rats. Moreover, this herb has been found to scavenge free oxygen radicals and inhibit nitric oxide generation, exerting antioxidative functions.

The objective of the present study is to investigate the neuroprotective effects of *Dendrobium huoshanense* against oxidative stress which has been implicated in many neurological diseases such as ischemia, Alzheimer's disease and Parkinson's disease.

Methodology

Cells: Undifferentiated SH-SY5Y cells

Pre-treatment: Undifferentiated SH-SY5Y cells in DMEM supplemented with 5% FBS were pre-treated with chemically extracted *Dendrobium huoshanense* for 24 hours.

Treatment: After removing *Dendrobium huoshanense* from the cells, they were treated with hydrogen peroxide at 400 μ M in DMEM with 2% FBS for 18 hours.

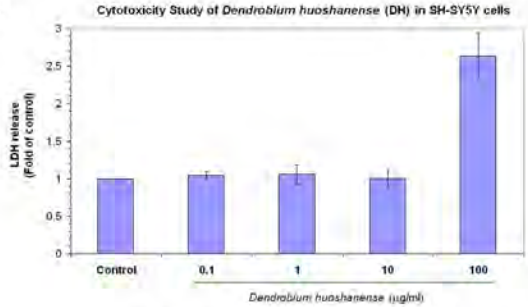
Cytotoxicity test: Measurement of LDH release

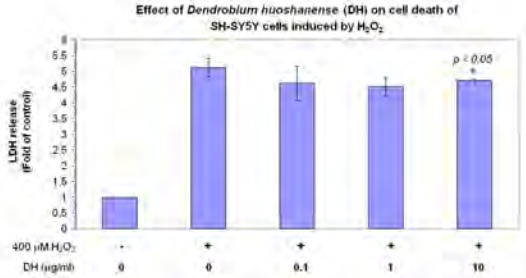
Discussion

Results indicated that pretreatment of *Dendrobium huoshanense* can reduce the release of lactate dehydrogenase from SH-SY5Y cells in hydrogen peroxide-induced toxicity, implicating that *Dendrobium huoshanense* may help in neuroprotection.

Contact information: Dr. K.C. Suen skc@plklfc.edu.hk

Results





SCIENCE EDUCATION

Poster Presented in the 43th Annual Meeting of Society for Neuroscience in 2013

Student's Research Project: Poster Presentation in the 45th Annual Meeting of Society for Neuroscience in Chicago, IL, USA in 2015

Differential effects of seed extracts of citrus fruits against hydrogen peroxide-induced toxicity in SH-SY5Y cells.

Suen K.C.[1], Tang W.S.[1], Hau P.C.[1], Ma H.H.[1], Chow P.C.[1], Hung Y.C.[1], Shi P.L.[1], Chau W.H.[1], Chan W.K.[1], Chang R.C.C.[2]

[1]Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, China

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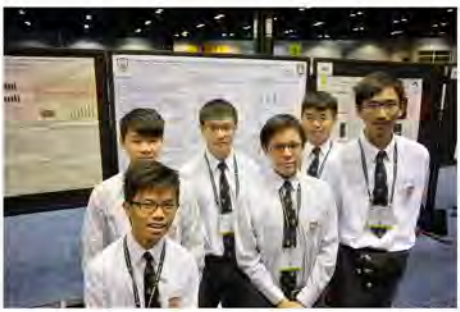
Some plant seed extracts have been reported to offer neuroprotection (Okada and Okada 2013; Yang et. al. 2012). The neuroprotective effects of seed extracts from *Citrus limon* (Common name: Lemon) and *Citrus margarita* (Common name: Kumquat) have not yet been studied. It is believed that oxidative stress is most likely to act in some neurodegenerative processes. Agents that have antioxidant effects may possess neuroprotective functions. In the present study, the neuroprotective effects of seed extracts from two types of citrus fruits which are *Citrus limon* and *Citrus margarita* are examined. The extracts were prepared by dissolving the powder of ground fresh seeds in DMSO or ethanol and insolubles were filtered out by 0.22 micrometer membrane filter. Non-differentiated SH-SY5Y cells were pre-treated with either *Citrus limon* or *Citrus margarita's* seed extract for 24 hours in DMEM supplemented with 2% fetal bovine serum. Following the removal of the seed extract, SH-SY5Y cells were treated with 500 microM of hydrogen peroxide for 24 hours in DMEM with 2% fetal bovine serum. Results indicated that the seed extract of Citrus margarita can significantly reduce toxicity induced by hydrogen peroxide. Yet, *Citrus limon's* seed extract did not show attenuation of hydrogen peroxide-induced cytotoxicity. This implicates that seed extracts from different types of citrus fruits may have different effects against toxicity induced by hydrogen peroxide. The present findings suggest that *Citrus margarita's* seed extract may offer neuroprotection.



Differential effects of seed extracts of citrus fruits against hydrogen peroxide-induced toxicity in SH-SY5Y cells

Ka-Chun Suen[1], Wing-Suen Tang[1], Pak-Chuen Hau[1], Ho-Him Ma[1], Pak-Chun Chow[1], Ying-Chin Hung[1], Pok-Lai Shi[1], Wai-Hin Chau[1], Wing-Kwong Chan[1], Raymond Chuen-Chung Chang[2]

[1]Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, China
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SfN 2015
Chicago, IL, US
689.03/J44

Introduction

It has been shown that some plant seed extracts could offer neuroprotection in Parkinson's disease model (Strathearn et al. 2014), beta-amyloid peptide induced neurotoxicity (Okada and Okada 2013), oxidative stress-induced apoptotic death (Yang et. al. 2012) and environmental pollutant-induced neurotoxicity (Yang et al. 2012).

The neuroprotective effects of whole-seed extracts from ***Citrus limon*** (Common name: Lemon) and ***Citrus margarita*** (Common name: Kumquat) have not yet been studied. As it is believed that oxidative stress is most likely to act in some neurodegenerative processes, agents that have antioxidant effects may possess neuroprotective functions.

The objective of the present study is to investigate the neuroprotective effects of seed extracts from two types of citrus fruits (*Citrus limon* and *Citrus margarita*) in oxidative stress-induced neurotoxicity.

Methodology

Cells: Undifferentiated SH-SY5Y cells

Seed extract: The powder of ground fresh seeds of *Citrus limon* or *Citrus margarita* was dissolved in DMSO or ethanol. Insolubles were filtered out by 0.22 mm membrane filter. The filtered extract was stored at 4°C before use.

Pre-treatment with seed extract: Undifferentiated SH-SY5Y cells in DMEM supplemented with 2% fetal bovine serum (FBS) were pre-treated with the seed extract for 24 hours.

Treatment with H_2O_2: After removing the seed extract from the cells, they were treated with H_2O_2 at 500mM in DMEM supplemented with 2% FBS for 24 hours.

Cytotoxicity test: Measurement of LDH release

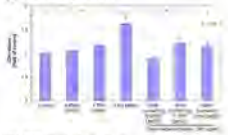
Statistical analysis: The data are expressed as mean of 3 experiments with error bar showing the standard error of the mean. The statistical analysis was done with One-way ANOVA by Post-hoc test of Bonferroni-Holm.

Contact information: Dr. K.C. Suen skc@plklfc.edu.hk

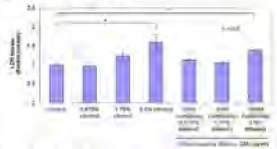
Results (*Citrus margarita*)

(A1) Cytotoxicity of whole-seed extract of *Citrus margarita*

(i) DMSO fraction

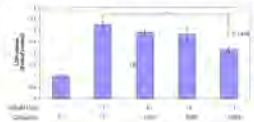


(ii) Ethanol fraction



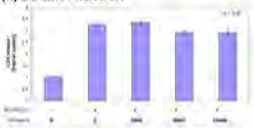
(B2) Effect of whole-seed extract of *Citrus margarita* (CM) against H_2O_2-induced toxicity of SH-SY5Y cells.

(i) DMSO fraction



The whole-seed extract of *Citrus margarita* significantly reduced H_2O_2-induced toxicity (in terms of LDH release) in SH-SY5Ycells.

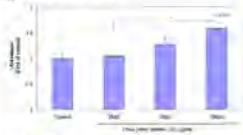
(ii) Ethanol fraction



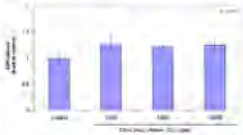
Results (*Citrus limon*)

(B1) Cytotoxicity of whole-seed extract of *Citrus limon*

(i) DMSO fraction

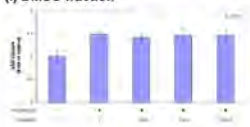


(i) Ethanol fraction



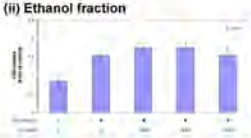
(B2) Effect of whole-seed extract of *Citrus limon* (CL) against H_2O_2-induced toxicity of SH-SY5Y cells.

(i) DMSO fraction



The whole-seed extract of *Citrus limon* had no significant reduction on H_2O_2 -induced toxicity (in terms of LDH release) in SH-SY5Ycells.

(ii) Ethanol fraction



Student's Research Project: Poster Presentation in the 47 th Annual Meeting of Society for Neuroscience in Washington DC, USA in 2017

The individual and multiple effects of Caulis Spatholobi, Salvia officinalis and Mentha citrata in hydrogen peroxide-induced neurotoxicity.

Ka-Chun Suen[1], Ting-Him Lee[1], Yan-Yuet Cheung[1], Coco Kit-Yung Cheung[1], King-Chung Wong[1], Sau-Tsun Chan[1], Chak-Yan Law[1], Cheuk-Lam Chau[1], Si-Wing Wong[1], Cheuk-Chee Mok[1], Wing-Yin Tsui[1], Ka-Yu Wan[1], Jasmine Suet-Ming Wong[1], Tsun-Ho Hsu[1], Wing-Suen Tang[1], Mei-Yu Lin[1] and Raymond Chuen-Chung Chang[2]

[1]Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, China

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Traditional Chinese medicine is usually formulated as a complex of herbs which may have synergistic effects for a disease. Sometimes, the overwhelming effect from a particular herb can be alleviated by antagonistic herbs. Therefore, mixtures of herbal ingredients may have advantages of multiple target regulation. *Caulis Spatholobi*, a commonly used herbal medicine for blood-activating and stasis-dispelling, has been reported to promote angiogenesis. Leaf and root extracts of *Salvia officinalis* (Common name: Sage) have been shown to have antiproliferative effects on hepatocellular carcinoma cells. *Mentha citrata* has been found to have antioxidative effects. In the present study, the individual and multiple effects of *Caulis Spatholobi* extract, seed extract of *Salvia officinalis* and leaf extract of *Mentha citrata* against hydrogen peroxide-induced neuronal cell death were studied. The extracts were prepared by dissolving the powder of ground *Caulis Spatholobi*, fresh sage seed and fresh Mentha's leaves in ethanol and insolubles were filtered out by 0.22 micro-meter membrane filter. Non-differentiated SH-SY5Y cells were pre-treated with a single or multiple extracts for 24 hours in DMEM supplemented with 2% fetal bovine serum. Following the removal of the extracts, SH-SY5Y cells were treated with 400 micro-molar of hydrogen peroxide for 24 hours in DMEM with 2% fetal bovine serum. Results indicated that there were differential effects of the extracts against hydrogen-peroxide induced cytotoxicity. This implies that some of the extracts may offer neuroprotection.

The individual and multiple effects of *Caulis Spatholobi*, *Salvia officinalis* and *Mentha citrata* in hydrogen peroxide-induced neurotoxicity

Ka-Chun SUEN[1], Ting-Him LEE[1], Yan-Yuet CHEUNG[1], Coco Kit-Yung CHEUNG[1], King-Chung WONG[1], Sau-Tsun CHAN[1], Chak-Yan LAW[1], Cheuk-Lam CHAU[1], Si-Wing WONG[1], Cheuk-Chee MOK[1], Wing-Yin TSUI[1], Ka-Yu WAN[1], Jasmine Suet-Ming WONG[1], Tsun-Ho HSU[1], Wing-Suen TANG[1], Mei-Yu LIN[1] and Raymond Chuen-Chung CHANG[2]

[1]Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong SAR, China

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SfN 2017
Washington DC, US
667.2 / S4

Introduction

In the present study, the neuroprotective effects of *Caulis Spatholobi*, seed extract of *Salvia officinalis* and leaf, stem and root extracts of *Mentha citrata* are studied.

Caulis Spatholobi (CS; also called Jixueteng; 雞血藤 in Chinese): It is the dried stem of *Spatholobus suberectus Dunn* (Leguminosae). The stem is collected in autumn and winter. With branches and leaves removed, the stem is cut into slices and dried under the sun to form *Caulis Spatholobi* (Reference: http://www.cmd.gov.hk/tharmacies/pdf/MP_pdf_English/D_Medicaments/20-SpatholobiRx20Caulis.pdf). It is known to have anti-tumour, anti-viral and antioxidant effects (Fu 2003; Gou et. al., 2010; Zhang and Wang, 2011; Zeng et. al., 2011).

Seed extract of Salvia officinalis (SO; 鼠尾草 in Chinese): *Salvia officinalis* belongs to the family Lamiaceae. Recent reports have indicated that it can enhance memory retention (Eidi et. al. 2006; Akhondzadeh et. al., 2003).

Leaf, stem and root extracts of *Mentha citrata* (MC; 薄荷 in Chinese): *Mentha citrata* is a herb. It has been shown to have antioxidant effects (Arumugam and Ramesh 2011).

Methodology

Cells: Undifferentiated SH-SY5Y cells

Preparation of extracts: *Caulis Spatholobi* / seeds of *Salvia officinalis* / leaf, stem or root of *Mentha citrata* was ground. The powder of each extract was dissolved in ethanol (molecular grade). Insolubles were filtered out by 0.22 μ m membrane filter. The filtered extract was stored at 4°C before use.

Pre-treatment with seed extract: Undifferentiated SH-SY5Y cells in DMEM supplemented with 2% fetal bovine serum (FBS) were pre-treated with the extract for 24 hours.

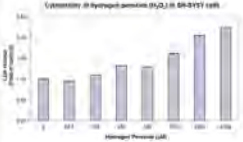
Treatment with H_2O_2: After removing the seed extract from the cells, they were treated with H_2O_2 at 400 μ M in DMEM supplemented with 2% FBS for 24 hours.

Cytotoxicity test: Measurement of LDH release

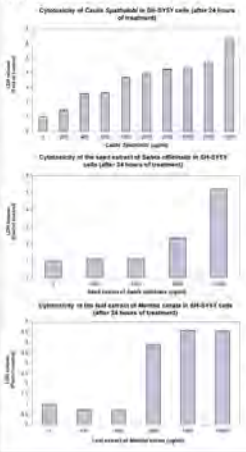
Statistical analysis: The data are expressed as mean of 3 experiments with error bar showing the standard error of the mean. The statistical analysis was done with One-way ANOVA by Post-hoc test of *Bonferroni-Holm*.

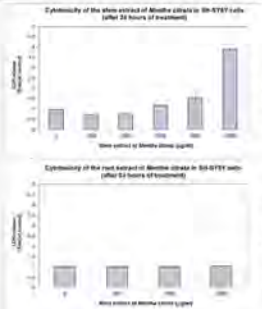
Results

(a) Neurotoxicity of H_2O_2

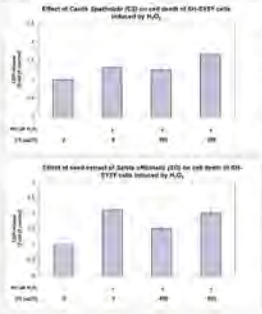


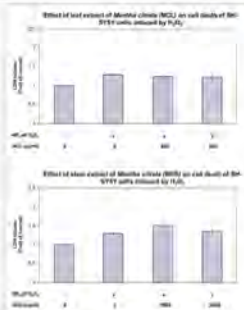
(b) Neurotoxicity of different extracts



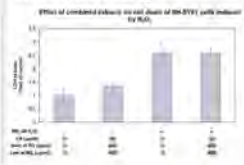


(c) Effects of different extracts in H_2O_2-induced neurotoxicity





(d) Effects of combined extracts in H_2O_2-induced neurotoxicity



Teacher's Educational Research: Poster Presentation in the 37 th Annual Meeting of Society for Neuroscience in San Diego, CA, USA in 2007

Research-Based Learning Associated With An Authentic Topic Can Promote Active Learning in High School Neuroscience Lessons.

Ka-Chun Suen[1], Wing-Kwong Chan[1] and Raymond Chuen-Chung Chang[2]

[1]Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, China

[2]Laboratory of Neurodegenerative Diseases, Department of Anatomy, LKS Faculty of Medicine, The University of Hong Kong, Pokfulam, Hong Kong, China

Memory is not an unfamiliar term to most high school students. They can easily construct the elementary meaning of memory based on their daily life experience about memory. Yet, they may not be interested in acquiring deeper understanding about memory as it involves both abstract and difficult topics such as neuroanatomy, brain physiology and neurotransmission. Traditional pedagogy to illustrate the physiology of memory is to provide students with a large amount of facts with diagrams about how memory forms. From our experience, this pedagogy does not effectively engage high school students in actively learning memory because it is not authentic to them. In the present study, we try to apply research-based learning (RBL) as a tool to engage high school students in linking the physiology of memory and daily life. We investigate whether the pedagogy of RBL associated with an authentic topic can promote students to actively learn difficult scientific concepts such as the mechanism of how memory forms. Methodology: With the supervision of a neuroscience teacher, two groups of four students aged 13-15 spent about 6 months to conduct two scientific researches titled "Doing physical exercise has no indication on learning and memory enhancement in children aged 13-15" and "Increment of sleeping time does not implicate enhancement on memory and learning in adolescents", respectively. These two topics were selected because the students were interested in understanding how to promote their ability to memorize for better learning efficiency. Assessment of learning was done through lesson observation, interview and student's outputs including a research report written as a scientific abstract and presentation. Results indicated that the students usually discussed their research. They also suggested many ways to improve their research. They showed a desire to see the final result of the research. Without any request from the project-supervising teacher, all participant students actively searched and read information about memory from the internet. Some specific terms about memory which are "hippocampus", "short-term memory" and "long-term memory" appear in their research products such as a scientific abstract and a poster for conference presentation. These pieces of evidence indicated that the students were actively learning the topics of memory through doing an authentic research. In conclusion, research-based learning associated with an authentic topic is an effective pedagogy to engage students in learning some difficult scientific concepts.

Poster Presented in the 37th Annual Meeting of Society for Neuroscience in 2007

Research-Based Learning Associated With An Authentic Topic Can Promote Active Learning in High School Neuroscience Lessons

Ka-Chun SUEN[1], Wing-Kwong CHAN[1], Raymond Chuen-Chung CHANG[2]

[1]Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, CHINA
[2]Laboratory of Neurodegenerative Diseases, Department of Anatomy, LI Ka Shing Faculty of Medicine, The University of Hong Kong, Pokfulam, Hong Kong, China

SfN 2007
29.8/PPP29

1 Introduction

Memory is not an unfamiliar term to most high school students. They can easily construct the elementary meaning of memory based on their daily life experience about memory. Yet, they may not be interested in acquiring deeper understanding about memory as it involves both abstract and difficult topics such as neuroanatomy, brain physiology and neurotransmission. Traditional pedagogy to illustrate the physiology of memory is to provide students with a large amount of facts with diagrams about how memory forms. From our experience, this pedagogy does not effectively engage high school students in actively learning memory because it is not authentic to them.

In the present study, we try to apply research-based learning (RBL) as a tool to engage high school students in linking the physiology of memory and daily life. We investigate whether the pedagogy of RBL associated with an authentic topic can promote students to actively learn difficult scientific concepts such as the mechanism of how memory forms.

2 Methodology

With the supervision of a neuroscience teacher, two groups of four students aged 13-15 spent about 6 months to conduct two scientific researches titled "Doing physical exercise has no indication on learning and memory enhancement in children aged 13-15" and "Increment of sleeping time does not implicate enhancement on memory and learning in adolescents", respectively. These two **authentic** topics were selected because the students were interested in understanding how to promote their ability to memorize for better learning efficiency. Assessment of learning was done through **lesson observation, interview and student's outputs** including a research report written as a scientific abstract and presentation.

3 Results

Qualitative evidence showing that active learning occurred among the students who conducted RBL in neuroscience lessons.

- The students usually discussed their research during and outside lesson hours.
- The students can provide constructive ideas for improving their research.
- The students actively searched for and read information (on the internet) and books about their research topics.
- Use of scientific terms like "short-term memory", "long-term memory" and "hippocampus" appeared in their learning products which were abstracts and PowerPoint presentation slides.

Student's generic skills were also enhanced in RBL. They include study skills, numeracy skills, critical thinking skills, communication skills, self-management skills, collaboration skills, problem solving skills and creativity.

4 Discussion and conclusion

Research-based learning associated with an authentic topic may help high school students learn difficult scientific concepts like memory and sleeping in neuroscience.

Contact information
Dr. K.C. Suen (kachuns@gmail.com)

Teacher's Educational Research: Poster Presentation in the 38th Annual Meeting of Society for Neuroscience in Washington DC, USA in 2008

Brain cell culture is an effective learning activity for high school students to acquire diverse knowledge and skills about neuroscience.

Ka-Chun Suen[1], Wing-Kwong Chan[1] and Raymond Chuen-Chung Chang[2]

[1]Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, China

[2]Laboratory of Neurodegenerative Diseases, Department of Anatomy, LKS Faculty of Medicine, The University of Hong Kong, Pokfulam, Hong Kong, China

Cell culture is a common tool in scientific research. By manipulating different culture conditions, scientists can study the morphological, biochemical and physiological changes of cells in response to variables. Due to the lack of cell culture facilities, teacher's training in handling cell culture experiments and suitable source of cells, brain cell culture is rarely introduced in high school neuroscience lessons. To our knowledge, we are the only high school in Hong Kong to employ brain cell culture in our school-based neuroscience curriculum which was established in the academic year of 2004-2005. The objective of the present report is to share our 4-year experience in employing brain cell culture in high school neuroscience lessons. First, what is the background of our neuroscience curriculum? Two main parts of the curriculum contents are (a) the basic components of the human nervous system and (b) how the nervous system works and when it does not work. Most of the contents will be delivered through the experiment- or problem-based learning mode within 2 years. All participating students will conduct a group or individual research project which lasts for a year. Our laboratory is equipped with a class II laminar culture hood and one inverted microscope connected with a digital video system. Second, how can brain cell culture help students construct knowledge? All participating students have opportunities to culture brain cells. Through cell culture, students acquire knowledge about neuronal structure and growth. By manipulating different stressful conditions to the cultured cells, students can understand the process of neuronal death which occurs in many neurodegenerative diseases. Students will also develop a variety of research skills when solving problems about brain cell culture. Third, is brain cell culture an effective learning activity to students? In terms of interest, all interviewed students replied that they liked culturing brain cells. Besides, teacher's observation indicates that active learning about the knowledge and skills associated with brain cell culture occurs among the participating students. Frequent discussion about brain cells is also observed. We conclude that brain cell culture is an effective learning activity for high school students to acquire diverse knowledge and skills about neuroscience.

Poster Presented in the 38th Annual Meeting of Society for Neuroscience in 2008

Brain cell culture is an effective learning activity for high school students to acquire diverse knowledge and skills about neuroscience.

Ka-Chun Suen[1], Wing-Kwong Chan[1], Raymond Chuen-Chung Chang[2]

[1]Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, China
[2]Laboratory of Neurodegenerative Diseases, Department of Anatomy, Li Ka Shing Faculty of Medicine, The University of Hong Kong, Hong Kong, China

SfN 2008,
Washington, DC, US
222.17/UU5

1 Introduction

Cell culture is a common tool in scientific research. By manipulating different culture conditions, scientists can study the morphological, biochemical and physiological changes of cells in response to variables. Due to the lack of cell culture facilities, teacher's training in handling cell culture experiments and suitable source of cells, brain cell culture is rarely introduced in high school neuroscience lessons. To our knowledge, we are the only high school in Hong Kong to employ brain cell culture in our school-based neuroscience curriculum which was established in the academic year of 2004-2005.

The objective of our present report is to share our 4-year experience in employing brain cell culture in high school neuroscience lessons. The sharing focuses on

(a) the learning objectives and pedagogies of our neuroscience curriculum,
(b) a teaching model of brain cell culture in neuroscience lessons and
(c) the evaluation of brain cell culture as a teaching activity in neuroscience.

Contact information

Dr. K.C. Suen (kachuns@gmail.com)

2 Learning objectives and pedagogies

(i) Learning objectives

Our neuroscience curriculum aims to equip students with basic ideas and concepts which will help them deal with personal, societal and economic issues related to neuroscience. There are two main parts in our neuroscience curriculum:

- the basic components of the nervous system in mammals
- how the nervous system works and when it does not work (Some topics about neurodegenerative diseases are included).

(ii) Pedagogies

There is no fixed teaching content in our neuroscience curriculum. How can students acquire neuroscience knowledge? Through

- problem-based learning,
- research-based learning and
- experiment-based learning,

students can acquire knowledge actively based on their need and interest. It is known that learning targets are embedded into each of the above learning activities.

We have reported that research-based learning associated with an authentic topic can promote active learning in high school neuroscience lessons (Suen et. al. 2007)

3 Teaching model of brain cell culture

(i) **Type of brain cell culture**: post-natal rat (1 day old).

Why are post-natal instead of pre-natal rats used? It is too difficult for junior form students to dissect a very small pre-natal rat brain. One of the learning objectives behind brain cell culture is to understand the structure of mammal brains. So, a practicable experiment in dissection is needed. One of the disadvantages in using post-natal rats is that the chance of neuronal survival is low. Also, there are many non-neurons growing on a culture plate. But, this may offer students another chance to understand that there are not only neurons in the brain but also some other types of brain cells.

(ii) **Studies involved in brain cell culture**

- Students study how to establish brain cell culture. So, they need to manipulate different conditions so that brain cells can survive in culture. In addition, students are able to observe the growth of brain cells.
- Students study when brain cells die. To create a stressful condition (e.g. adding H_2O_2 in cultures), students can understand why neurons die in neurodegenerative diseases.
- Students study how to save brain cells from the stressful condition. Then, the students can develop an understanding on how drug discovery is done for the treatment of diseases.

(iii) **Evaluation of brain cell culture as a teaching activity**

- All students who had a chance to work on brain cell culture indicated that they were interested in it.
- From teacher's observation, the students actively did all experiments and looked for improvement for their neuroscience studies.
- The students also conducted group discussion outside lesson hours.

Teacher's Educational Research: Poster Presentation in the 40th Annual Meeting of Society for Neuroscience in San Diego, CA, USA in 2010

Development of a school-based neuroscience curriculum in a high school in Hong Kong.

Ka-Chun Suen[1], Wing-Kwong Chan[1] and Raymond Chuen-Chung Chang[2]

[1]Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, China

[2]Laboratory of Neurodegenerative Diseases, Department of Anatomy, LKS Faculty of Medicine, The University of Hong Kong, Pokfulam, Hong Kong, China

We are the pioneer to develop a school-based neuroscience curriculum in a high school in Hong Kong. Although the functions and basic structure of the brain and neurons, neuromuscular junction, neurotransmission, spinal reflexes, roles of cone and rod cells in vision and cochlea in audition are included in Hong Kong's high-school science curricula including Integrated Science and Biology, a comprehensive neuroscience curriculum and neuroscience teachers to cultivate young neuroscientists and to raise student's awareness and understanding on some common neurodegenerative diseases such as Alzheimer disease and Parkinson's disease are absent. Since 2004, our school has set up a school-based neuroscience program in which research-based learning mode is applied to engage students in learning neurodegenerative diseases. Neuronal cell culture is also included as a tool for students to study the growth and death of neurons. To further promote neuroscience education, student's participation in neuroscience research and attendance in neuroscience conferences are encouraged. Collaboration with neuroscientists in university is highly supportive to neuroscience education in our school. To further develop the school-based neuroscience curriculum, more diverse examples about neuroscience such as studies on invertebrate nervous system will be introduced. To evaluate our school-based neuroscience curriculum, student's awareness and interest on neuroscience are enhanced. This implicates that our school-based neuroscience curriculum is constructive to the neuroscience education in our school.

Development of a school-based neuroscience curriculum in a high school in Hong Kong.

Ka-Chun Suen[1], Wing-Kwong Chan[1], Raymond Chuen-Chung Chang[2]

[1]Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, China
[2]Laboratory of Neurodegenerative Diseases, Department of Anatomy, Li Ka Shing Faculty of Medicine, The University of Hong Kong, Hong Kong, China

SfN 2010,
San Diego, CA, US
23.5/NNN44

1 Introduction

Neuroscience education in Hong Kong

(i) Curriculum Although the functions and basic structure of the brain and neurons, neuromuscular junction, neurotransmission, spinal reflexes, roles of cone and rod cells in vision and cochlea in audition are included in Hong Kong's high-school science curricula including Integrated Science (I.S.) for junior form students and Biology for senior form students, a comprehensive neuroscience curriculum to cultivate young neuroscientists and to raise student's awareness and understanding on some common neurodegenerative diseases such as Alzheimer's disease and Parkinson's disease is absent.

(ii) Teacher training Teachers of I.S. or biology receive inadequate teacher training on neuroscience-related topics. Moreover, many of the science teachers do not engage in any neuroscience issues in their university-level studies.

The objective of our present report is to share our 6-year experience in the development of a school-based neuroscience curriculum in a high school in Hong Kong. The sharing focuses on (a) **curriculum contents**, (b) **pedagogies** applied in neuroscience lessons, (c) a **pull-out gifted education training program** and (d) **teacher's professional development** in neuroscience education.

Contact information

Dr. K.C. Suen (skc@plklfc.edu.hk)

2 Development of a school-based neuroscience curriculum

Background of our neuroscience lessons

Our neuroscience lessons are run as an extra-curricular activity after regular school lessons. Students who show interest in neuroscience are welcome to join a 2-hour lesson every week. Each class is composed of not more than 16 students ranging from grade 7-10. There are about 28 lessons (~56 teaching hours) each academic year.

(a) Curriculum contents

Our neuroscience curriculum aims to equip students with basic ideas and concepts about how the brain and its associated parts work to achieve diverse coordination tasks, memory formation and occurrence of learning. In addition, authentic problems of neurodegenerative diseases are introduced to raise student's interest in neuroscience.

Some of the topics of our neuroscience curriculum are shown below:
(i) **brain anatomy**, (ii) **structure and functions of neurons**, (iii) **human brain development**, (iv) **neuronal cell culture**, (v) **neuronal growth and death**, (vi) methodology of **pharmacological studies** on cultured neurons and (vii) **neurodegeneration** demonstrated by Alzheimer's disease and Parkinson's disease.

(b) Pedagogies

As neuroscience is a science subject, neuroscience education has a role to develop student's scientific literacy. In addition, to raise students' interest in neuroscience, we adopt experiment-based, problem-based and research-based learning in neuroscience lessons.

Selected examples of the pedagogies applied:
(i) **Experiment-based learning** - Through culturing rat neurons, students can practically know how neurons develop in terms of morphology. The morphological changes of neurons in cell death can also be viewed at different periods of the cell death process.
(ii) **Problem-based learning** - (1) Can neurons have a longer life if they are fed with coca-cola? (2) What would happen if neurons get "fevered"?
(iii) **Research-based learning** - The following are the titles of the research presented in previous SfN annual conference by our students: (1) Doing physical exercise has no indication on learning and memory enhancement in children aged 13-15. (2) Increment of sleeping time does not implicate enhancement on memory and learning in adolescents. (3) Immediate night-time sleep helps memory consolidation in adolescents aged 13-14. (4) Elicitation of a pungent sensation does not implicate memory modulation in adolescents aged 14-16.

(c) Pull-out gifted education training program

Some students who are gifted in neuroscience were selected to join the SfN annual conference as a pull-out program to widen their horizons in neuroscience research. Two different batches of students joined the 36th and 38th SfN annual meeting respectively. After the conference meeting, all of the students showed an active engagement to modify and further develop their new research project.

(d) Teacher's professional development

Teachers who develop the present neuroscience curriculum have published two abstracts on the pedagogies applied in the neuroscience lessons.

Teacher's Educational Research: Poster Presentation in the 3rd Biennial Conference of East-Asian Association for Science Education in Hong Kong in 2013

An example of a high school in Hong Kong to develop a school-based neuroscience curriculum as a pull-out program for scientifically gifted students.

Ka-Chun Suen[1,2], Kit-Yan Chu[1], Raymond Chuen-Chung Chang[2] and Wing-Kwong Chan[1]

[1]Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, China

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Like all secondary schools in Hong Kong, our school provides Integrated Science for all of our junior form (Secondary 1 - 3) students. To further help them develop interest and acquire knowledge in science, a school-based biotechnology curriculum has been established based on Renzulli's enrichment triad model since 2004. The biotechnology lessons have a role as a whole-class gifted curriculum in which scientifically gifted students are able to conduct investigation of real problems. As we observed that these gifted learners were highly curious about and interested in new topics and needed more challenging tasks, as similarly reported by other educationists (Yang et. al. 2012; Davis et. al. 2011), a pull-out neuroscience class titled "Neuroscience Club" was established to help identified gifted students to further develop their scientific literacy, curiosity and interest in science. While most students have learnt a few topics about neuroscience, our neuroscience curriculum is designed based on the Purdue Three-Stage model and targets to provide the scientifically gifted for experience to be a scientist to solve novel questions. The present report aims to share practical experience and procedures to establish a pull-out gifted program in science based on the Purdue Three-Stage model. Qualitative data from lesson observation, interviews and teacher's reflection were employed to evaluate the neuroscience curriculum as a pull-out gifted program. The procedures of the development of pull-out neuroscience curriculum are discussed as follows: (1) Why neuroscience? As most junior form students in Hong Kong are not familiar with neuroscience, it is chosen to give them new challenges. (2) The gifted pupils are identified based on their academic results in the science subjects, teacher's recommendation, self recommendation and interview assessing students' ability to do scientific investigation. (3) About the Purdue Three-Stage model, students in group are asked to present the structure and functions of the nervous system at stage 1. At stage 2, each group studies a health problem related to the nervous system (e.g. Alzheimer's disease and Parkinson's disease). At stage 3, students are asked to conduct a scientific research to look for treatment against the diseases. To further provide students for challenges, they are asked to present their research data in international conferences in which the gifted learners can explore the variety of researches and scientific knowledge. Evaluation of the pull-out neuroscience lessons indicated that all scientifically gifted students participating in Neuroscience Club showed high commitment in their research. This suggests that the scientifically gifted students get achievement and encouragement of interest from the pull-out neuroscience program.

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Poster Presented in the 3rd Biennial Conference of East-Asian Association for Science Education in 2013

An example of a high school in Hong Kong to develop a school-based neuroscience curriculum as a pull-out program for scientifically gifted students.

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EASE 2013

Introduction

Our belief in science education

We believe that science education is for (i) meeting personal needs, (ii) nurturing scientific mind, creativity and curiosity, (iii) breeding informed and accountable citizens and (iv) preparing our students for further studies (Goodrum 2001; Yager 1990).

Science curriculum in our school

Integrated Science All of our junior form students have 3 Integrated Science lessons per week. There are nearly 100 hours of Integrated Science lessons in an academic year. The curriculum contents follow the syllabus prepared by The Curriculum Development Council, Hong Kong published in 1998. To promote student's interest and literacy in science, two recent schemes have been launched: (i) Joint-school science conference in which our S.1 students and our through-train primary school P.6 students presented their invention products or investigative projects in a science conference held by our two schools and (ii) development of a student portfolio in learning science.

Biotechnology curriculum Our school has developed a school-based Biotechnology curriculum for all S.1-3 students since 2004. The curriculum design is based on the Renzulli's enrichment trial model. For details, please visit our poster (*Poster code: PS-112*) titled "Effectiveness of the school-based Biotechnology curriculum — a science gifted programme for all" in EASE 2013.

School-based Neuroscience curriculum As we observed that our students were highly curious about and interested in new science topics and need more challenging tasks in science, as similarly reported by other educationists (Yang et. al. 2012; Davis et. al. 2011), a pull-out neuroscience class named "Neuroscience Club" was established. Initially, Neuroscience Club was just an extra-curricular activity for students to explore Neuroscience issues. Now, it becomes a school-based pull-out program for our scientifically gifted students and its curriculum is designed based on the Purdue Three-Stage Model.

Objective

The present report aims to share the practical experience and procedures to establish a pull-out gifted program in neuroscience based on the Purdue Three-Stage Model.

As there are five essential components in the Purdue Three-Stage Model to create an appropriately challenging learning environment for gifted students (Moon et. al. 2009), the present report will focus on these five components: (a) program goals, (b) student selection, (c) grouping structures of students, (d) teacher's training and (e) curriculum and instruction.

(a) Program goals

- To further develop students' motivation in science;
- To encourage students to pursue an independent scientific investigation over a period of time (i.e. at least one year). (Thus, students would have to develop commitment in Neuroscience Club.);
- To assist students in understanding and applying the scientific method;
- To provide students for opportunities to conduct professional scientific investigation;
- To assist students in reporting their experimental results at the international levels;
- To support students to participate in scientific conferences to exchange findings and insights with scientists;

The above goals were similar to the learning objectives in Science Research Class developed by Whitman & Moon in 1993.

(b) Student selection

Multiple indicators were developed to identify and select scientifically gifted students in our school to join Neuroscience Club:

- Academic results in Integrated Science: > 80%
- Academic results in Biotechnology: > 80%
- Teacher's observation on student's talents in daily science lessons (For example, a student can demonstrate a high ability to do investigation. A student who can show in-depth reflection on science-related daily-life issues in the science portfolio would be recruited.)
- Reading habit (For example, a student likes reading science books.)
- Interview which students were asked to design an experiment to study a neuroscience-related issue (like the Purdue Academic Rating Scales (PARS) (Feldhusen et. al. 1990))

(c) Grouping structures of students

In order to provide gifted students for more opportunities to interact with intellectual peers, students of a similar class level worked in a group in Neuroscience Club. Usually, 2-4 students who had better friendship were grouped together so as to further promote a long-term positive impact on the cognitive, affective and social development of most participating students.

(d) Teacher's training

The teacher who supervised Neuroscience Club had received both basic and advanced training in developing a gifted curriculum. More importantly, the teacher learnt different models of gifted education by reading journal articles and kept developing the curriculum contents of Neuroscience Club through doing action research and educational research.

(e) Curriculum and instruction

	Learning activities	Proportion of learning time
Stage I	Lessons about brain anatomy, structure and functions of neurons, human brain development, memory, sleep and physiological basis of neurodegenerative diseases	15% (~15 hours per year)
Stage II	Brain cell culture, microscopic observation on the development of neurons, pharmacological studies, presentation task of literature review of a topic and problem-based learning e.g. (1) Can neurons have a longer life if they are fed with coca-cola? (2) What would happen if neurons get "fevered"?	15% (~15 hours per year)
Stage III	Students conducted research on various topics. In the past, the research topics included sleep, memory, pungent smell, neuronal cell death and neuroprotective studies. Besides, students were supported to present their research findings in international conferences.	70% (~70 hours per year)

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Teacher's Educational Research: Poster Presentation in the 43rd Annual Meeting of Society for Neuroscience in San Diego, CA, USA in 2013

A neuroscience pull-out gifted program in a high school in Hong Kong: Connection of neurodegenerative diseases and traditional Chinese medicine in research-based learning.

Ka-Chun Suen[1], Man-Ho Li[1], Wing-Kwong Chan[1], Raymond Chuen-Chung Chang[2]

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[2]Laboratory of Neurodegenerative Diseases, Department of Anatomy, LKS Faculty of Medicine, The University of Hong Kong, Pokfulam, Hong Kong, China

In 2010, we reported the development of a school-based neuroscience curriculum in a Hong Kong's high school (Suen et. al. 2010). The curriculum highlighted brain cell culture and research-based learning as effective learning activities (Suen et. al. 2008; Suen et. al. 2007). In recent years, we have started developing a neuroscience pull-out program for the students who are scientifically gifted in science (Suen et. al. 2013). In the present report, we describe and evaluate how the gifted students learn neuroscience and develop scientific literacy through doing a scientific research in which neurodegenerative diseases and traditional Chinese medicine are connected. Learning areas related to neurodegenerative diseases may include brain structure, brain functions, structure of neurons, communication between neurons, mechanisms of neuronal cell death and some physiological basis of the diseases. Yet, neurodegenerative diseases are not mentioned in high-school science curricula (integrated science in junior forms and biology in senior forms) in Hong Kong. While traditional Chinese medicine is not unfamiliar in our city, students have rare opportunities in school to conduct learning activities about Chinese herbs. In our neuroscience pull-out gifted program, we aim to develop research-based learning activities in which neurodegenerative diseases and traditional Chinese medicine are introduced and connected. Four scientifically gifted students aged 14-15 were invited to join this pull-out program. They carried out the following tasks in 4 cycles within 6 months: doing literature research on neurodegenerative diseases, studying the common neuroprotective effects of some traditional Chinese medicine, looking for any traditional Chinese medicine which may be potentially neuroprotective against neurodegenerative diseases, setting up experimental models and carrying out the experiments to study the neuroprotective effects of traditional Chinese medicine and acquiring laboratory skills to do cell culture and extract ingredients from the herbal medicine. Peer's assessment among students, teacher's observation on each of the above tasks, practical skills assessment and paper-and-pencil tests about basic neurobiology and nature of science indicated that scientifically gifted students can further develop their scientific literacy and acquire neuroscience knowledge through doing a 6-month scientific research in which neurodegenerative diseases and traditional Chinese medicine were highlighted and connected.

A neuroscience pull-out gifted program in a high school in Hong Kong: Connection of neurodegenerative diseases and traditional Chinese medicine in research-based learning

Ka-Chun Suen[1], Man-Ho Li[1], Wing-Kwong Chan[1], Raymond Chuen-Chung Chang[2]

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Introduction

The development of Neuroscience curriculum in our school (a high school in Hong Kong): *Published previously in*

2007 Research-based learning associated with an authentic topic can promote active learning in high school neuroscience lessons
2008 Brain cell culture is an effective learning activity for high school students to acquire diverse knowledge and skills about neuroscience
2010 Development of a school-based neuroscience curriculum in a high school in Hong Kong
2013 An example of a high school in Hong Kong to develop a school-based Neuroscience curriculum as a pull-out program for scientifically gifted students

In our school, the Neuroscience curriculum mentioned above was run by Neuroscience Club which was a pull-out class for the scientifically gifted students.

The Purdue Three-Stage Enrichment Model (Feldhusen 1973) was adopted in our pull-out Neuroscience class to move students from simple thinking experiences to complex independent activities (VanTassel-Baska 2007).

The Objective of our present report

To study how neurodegenerative diseases and traditional Chinese medicine can be connected as learning activities in the Purdue Three-Stage Enrichment Model in the pull-out Neuroscience curriculum.

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Curriculum design

As there was no any topic about neurodegenerative diseases and traditional Chinese medicine in high-school science curricula in Hong Kong, we introduced them in our pull-out neuroscience program as challenging and enriching learning topics in science.

Neurodegenerative diseases and traditional Chinese medicine were then connected as learning activities in the Purdue Three-Stage Enrichment Model as follows:

Stage I:

Learning objective	Mastery of core contents on brain structure, morphology of neurons, characteristics of neuronal cell death and basic chemistry (e.g. concentration); Mastery of technical skills on cell culture
Learning activities	Taught class, self reading and student's presentation on selected topics

Stage II:

Learning objective	Mastery of the above core contents with enhancement on complex problem-solving abilities
Learning activities	Practical preparation of different concentrations of extracted traditional Chinese medicine; literature review on agents which can cause neuronal cell death in Alzheimer's disease; investigation on different concentrations of the toxic agents (e.g. H_2O_2) to kill neurons; investigation on the morphological changes in neurons treated with the toxic agents; literature review on the functions of traditional Chinese medicine

Stage III:

Learning objective	Development of student's abilities to apply knowledge to solve real problems as a scientist
Learning activities	**Research-based learning: Students in groups develop a scientific research to study the neuroprotective effects of traditional Chinese medicine in neuronal cells.**

Stage-III learning activities were repeated when students started a study on a new traditional Chinese medicine.

Evaluation

Four scientifically gifted students aged 14-15 were identified and selected to join Neuroscience Club. They did stage-I and stage-II activities once. These pupils repeated stage-III activities for 4 times (i.e. studying 4 types of traditional Chinese medicine) within 6 months.

Qualitative data by teacher's observation:

1. All of the students showed high **interest** towards looking for medicine to rescue neurons.
2. The students were able to **plan and conduct 5-day experiment** (seed cells, grow cells, pre-treat cells with Chinese medicine, treat cells with H_2O_2 and do LDH essay for cell death study).
3. In terms of **data accuracy**, the students had developed a sense of repeating experiments.
4. The students were able to do a **fair test.**
5. About the Nature of Science, the students realized the **limitations of science** and scientific methods.

Teacher's Educational Research: Poster Presentation in the 3rd Biennial Conference of East-Asian Association for Science Education in Hong Kong in 2013

Effectiveness of the school-based Biotechnology curriculum – a science gifted programme for all.

Kit-Yan Chu, Mei-Yu Lin, Ka-Chun Suen and Wing-Kwong Chan

Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, China

A school-based gifted programme for all – Biotechnology has been established for all junior form students (Key stage 3, Form 1 to 3) since 2004. The design of the school-based Biotechnology curriculum is based on the Renzulli's enrichment triad model (1977) in which Type 1 – General Exploratory Activities, Type 2 – Group Training Activities and Type 3 – Investigation of Real Problems are included. The present study aims at evaluating the effectiveness of this school-based gifted programme – Biotechnology. As suggested by Rimm (1994), a gifted curriculum can be evaluated at its (1) Input, (2) Process and (3) Outcomes. Questionnaires were used to collect students' views on the curriculum. Key findings of this study are: (1) Input – teachers are qualified and passionate; and the biotechnology laboratory is well equipped; (2) Process – (a) Students' interests in studying Biotechnology as well as other areas of Science have been enhanced as they proceed from Form 1 to 3; (b) Students' interests on microbial cultures, cell culture and DNA extraction are particularly strong; (c) Students appreciate the experimental work the most; (3) Outcome – students' high-order thinking skills, creativity as well as ability to address science-related social issues are augmented as reflected from both summative and formative assessments. The findings from this study shed light on how Biotechnology can be effectively deployed as a school-based gifted programme for all.

Poster Presented in the 3rd Biennial Conference of East-Asian Association for Science Education in 2013

Effectiveness of the school-based Biotechnology curriculum – a science gifted programme for all

CHU Kit Yan*, LIN Mei Yu, SUEN Ka Chun and CHAN Wing Kwong
Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong SAR, P.R. China

Abstract

A school-based gifted programme for all – Biotechnology has been established for all junior form students (Key stage 3, Form 1 to 3) since 2004. The design of the school-based Biotechnology curriculum is based on the Renzulli's enrichment triad model (1977) in which Type 1 – General Exploratory Activities, Type 2 – Group Training Activities and Type 3 – Investigation of Real Problems are included. The present study aims at evaluating the effectiveness of this school-based gifted programme – Biotechnology. As suggested by Rimm (1994), a gifted curriculum can be evaluated at its (1) Input, (2) Process and (3) Outcomes. Questionnaires were used to collect students' views on the curriculum. Key findings of this study are: (1) Input – teachers are qualified and passionate; and the biotechnology laboratory is well equipped; (2) Process – (a) Students' interests in studying Biotechnology as well as other areas of Science have been enhanced as they proceed from Form 1 to 3; (b) Students' interests in microbial cultures, cell culture and DNA extraction are particularly strong; (c) Students appreciate the experimental work the most; (3) Outcome – students' high-order thinking skills, creativity as well as ability to address science-related social issues are augmented as reflected from both summative and formative assessments. The findings from this study shed light on how Biotechnology can be effectively deployed as a school-based gifted programme for all.

❶ Introduction

A school-based gifted programme for all – Biotechnology has been established for all junior form students (Key stage 3, Form 1 to 3) since 2004. Based on the Renzulli's enrichment triad model (1977), Type 1 – General Exploratory Activities, Type 2 – Group Training Activities and Type 3 – Investigation of Real Problems are provided to enrich students' science learning.

❷ Aim

To evaluate the effectiveness of this school-based gifted programme – Biotechnology in terms of (1) Input, (2) Process and (3) Outcomes.

❸ Methodology

Questionnaires were used to collect students' views on the curriculum.

❹ Key Findings

(1) Input
Teachers are qualified and passionate; and the biotechnology laboratory is well equipped.

(2) Process
- Students' interests in studying Biotechnology as well as other areas of Science have been enhanced as they proceed from Form 1 to 3.

- Students' interests in microbial cultures, cell culture and DNA extraction are particularly strong.

- Students appreciate the experimental work the most.

	Topics	Experiments	Teacher	Assessment	Laboratory equipment
S.1	7.9 %	83.5 %	5.8 %	0.7 %	2.2 %
S.2	15.6 %	66.7 %	15.6 %	1.5 %	0.7 %
S.3	23.4 %	58.6 %	14.8 %	3.1 %	0.0 %

(3) Outcome
Students' high-order thinking skills, creativity as well as ability to address science-related social issues are augmented as reflected from both summative and formative assessments.

Interest in learning science:
- Students are always engaged in doing experiments.
- Students suggest some experiments which cannot be found in the I.S. and biotechnology.
- Students sometimes raise questions about recent issues of biotechnology .

Curiosity in science
- Students usually suggest more variables to test the hypothesis. For example, students are curious about the possibility of the co-culture of animal cells and plant cells.
- Students would like to investigate matters in a multi-factorial manner.

Concerns in the ethical and societal issues related to biotechnology
- Students sometimes raise questions about ethical issues of biotechnology during/after the lesson. For example, should we eat green fluorescent chickens?

❺ Implication

The findings from this study shed light on how Biotechnology can be effectively deployed as a school-based gifted programme for all.

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Teacher's Educational Research: Poster Presentation in the 3rd Biennial Conference of East-Asian Association for Science Education in Hong Kong in 2013

How Nature of Science (NOS) can be infused to students through "Grassroom" in the sky?

Kit-Yan Chu, Mei-Yu Lin, Ka-Chun Suen and Wing-Kwong Chan

Po Leung Kuk Laws Foundation College, Tseung Kwan O, Hong Kong, China

"Grassroom" in the sky is an interactive classroom transformed from an idle rooftop at Po Leung Kuk Laws Foundation College. Apart from the overwhelming environmental benefits of a green roof and the energy savings to the school, the "Grassroom" also provides a number of environmental educational opportunities as well as a research-based learning platform in a real life environment for students. The present study aims at demonstrating how different aspects and kinds of Nature of Science (NOS) are infused to students through different research-based learning activities at the "Grassroom". Mind maps were given to students before and after participating in the research-based activities to complete what "Science is, requires and involves". Results have shown different items and aspects of Nature of Science (NOS) in students have been enhanced through different kinds of the research-based studies. Most notably are: (1) The major steps in scientific inquiry include: observation, asking questions, proposing hypotheses, making predictions and testing the hypotheses, drawing conclusions; (2) Scientific investigations all begin with a question on some natural phenomena; (3) Scientists have to explore with different techniques and methods to find the best solution to a problem; (4) Research conclusions should neither be over-cautious nor over-generalized; (5) The success of scientific investigation is the result of dedication and ingenuity; and (6) Science is affected by the technology and equipment available at the time. The findings from this study shed light on how research-based learning on the "Grassroom" can infuse the ideas of Nature of Science (NOS) in students profoundly.

Poster Presented in the 3rd Biennial Conference of East-Asian Association for Science Education in 2013

How can Nature of Science (NOS) be infused to students through "Grassroom" in the sky?

CHU Kit Yan*, LIN Mei Yu, SUEN Ka Chun and CHAN Wing Kwong
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Abstract

"Grassroom" in the sky is an interactive classroom transformed from an idle rooftop at Po Leung Kuk Laws Foundation College. Apart from the overwhelming environmental benefits of a green roof and the energy savings to the school, the "Grassroom" also provides a number of environmental educational opportunities as well as a research-based learning platform in a real life environment for students. The present study aims at demonstrating how different aspects and kinds of Nature of Science (NOS) are infused to students through different research-based learning activities at the Grassroom. Mind maps were given to students before and after participating in the research-based activities to complete what "Science is, requires and involves". Results have shown different items and aspects of Nature of Science (NOS) in students have been enhanced through different kinds of the research-based studies. Most notably are: (1) The major steps in scientific inquiry include: observation, asking questions, proposing hypotheses, making predictions and testing the hypotheses, drawing conclusions; (2) Scientific investigations all begin with a question on some natural phenomena; (3) Scientists have to explore with different techniques and methods to find the best solution to a problem; (4) Research conclusions should neither be over-cautious nor over-generalized; (5) The success of scientific investigation is the result of dedication and ingenuity; and (6) Science is affected by the technology and equipment available at the time. The findings from this study shed light on how research-based learning on the "Grassroom" can infuse the ideas of Nature of Science (NOS) in students.

❶ Introduction

"Grassroom" in the sky is an interactive classroom transformed from an idle rooftop at Po Leung Kuk Laws Foundation College. Apart from the overwhelming environmental benefits of a green roof and the energy savings to the school, the "Grassroom" also provides a number of environmental educational opportunities as well as a research-based learning platform in a real life environment for students.

❷ Aim

The present study aims at demonstrating how different aspects and kinds of Nature of Science (NOS) are infused to students through different research-based learning activities at the "Grassroom".

❸ Methodology

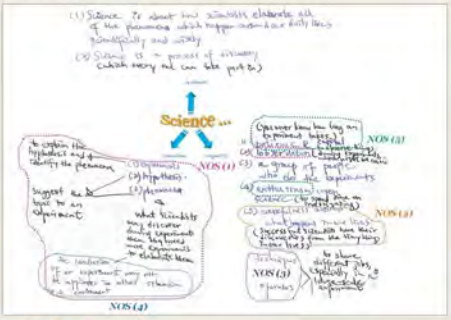
Mind maps were given to 25 students ***before*** and ***after*** participating in the research-based activities to complete what "Science is, requires and involves".

❹ Key Findings

Results have shown different items and aspects of Nature of Science (NOS) in students have been enhanced through different kinds of the research-based studies:

Nature of Science (NOS) enhanced
(1) The major steps in scientific inquiry include: **observation, asking questions, proposing hypotheses, making predictions and testing the hypotheses, drawing conclusions**;
(2) Scientific investigations all begin with a **question on some natural phenomena**;
(3) Scientists have to explore with **different techniques and methods** to find the best solution;
(4) Research conclusions should **neither be over-cautious nor over-generalized**;
(5) The success of scientific investigation is the result of **dedication and ingenuity**;
(6) Science is affected by the **technology** and **equipment available** at the time.

One exemplar is shown below:



Before participation: Blue
*After participation: **Black***

❺ Implication

The findings from this study shed light on how research-based learning on the "Grassroom" can infuse the ideas of Nature of Science (NOS) in students.

Reference

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Idle Rooftop


Interactive Grassroom


Evaluating biodiversity


Measuring temperature


Analyzing microbial diversity

Teacher's Educational Research: Poster Presentation in the 45th Annual Meeting of Society for Neuroscience in Chicago, IL, USA in 2015

Evaluation of five learning activities associated with live-cell imaging microscopy in a high school neuroscience curriculum for scientifically gifted students.

Ka-Chun Suen[1], Wing-Suen Tang[1], Wing-Kwong Chan[1], Raymond Chuen-Chung Chang[2]

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We established a pull-out neuroscience curriculum for scientifically gifted students in 2013. It was developed based on the Purdue Three-Stage Enrichment Model in which students experienced to be an advanced learner to conduct research-based learning (stage III) following a series of mastery activities for understanding of basic neuroscience contents (stage I) and enhancement of problem-solving skills (stage II) (Suen et. al. 2013). We reported that brain cell culture was an effective learning activity for high school students to learn diverse knowledge and skills about neuroscience (Suen et. al. 2008). Live-cell microscopy has become a useful tool to acquire a better understanding of biological functions. In the present study, five new learning tasks associated with cell culture and live-cell imaging microscopy are developed as the mastery activities to help scientifically gifted students acquire some basic knowledge and research skills in neuroscience (stages I and II) prior to the implementation of research-based learning (stage III). These activities were designed to help students visualize the continuous stages of the growth, development and death of brain cells. The students were instructed to capture time-lapse micrographs using a live-cell imaging system to study (1) mitotic cell division of SH-SY5Y cells, (2) differentiation of SH-SY5Y cells by retinoic acid, (3) induction of cell death of SH-SY5Y cells by different kinds of toxins including oxidative stress inducer (e.g. hydrogen peroxide), ER stress inducer (e.g. thapsigargin), high glucose content and heavy metal (e.g. lead), (4) positional and structural changes in organelles which are stained with fluorescent dyes (e.g. ER tracker and mitotracker) and (5) expression of green fluorescent protein (GFP) in SH-SY5Y cells after transfection with the GFP gene. The effectiveness of each of the activities to promote student's understanding on neuroscience knowledge as well as student's interest to work on an independent research project is evaluated. Results indicated that the learning activities associated with live-cell imaging microscopy can promote the learning interest and scientific literacy of the gifted students. This suggests that learning tasks associated with a live-cell imaging system can be applied in neuroscience gifted programs in high schools.

Evaluation of five learning activities associated with live-cell imaging microscopy in a high school neuroscience curriculum for scientifically gifted students

Ka-Chun Suen[1], Wing-Suen Tang[1], Wing-Kwong Chan[1], Raymond Chuen-Chung Chang[2]

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SfN 2015
Chicago, IL, US
22.04SU/CC28

Introduction

Background:

We are a high school in Hong Kong to develop a school-based neuroscience curriculum since 2004. There are three highlights in this school-based neuroscience curriculum:

(1) research-based learning is adopted (Suen et al. 2007);
(2) neuronal cell culture is a key practical skill for students to acquire (Suen et al. 2008); and
(3) a pull-out neuroscience curriculum is established for scientifically gifted students (Suen et al. 2013).

Our pull-out neuroscience curriculum is developed to nurture scientifically gifted students based on the Purdue Three-Stage Enrichment Model. These three stages apply a series of mastery learning activities to help students acquire various knowledge and practical skills in neuroscience (Suen et al. 2013). Briefly,

- ***Stage 1*** focuses on understanding of basic neuroscience knowledge;
- ***Stage 2*** aims at enhancement of practical skills and research skills;
- ***Stage 3*** adopts research-based learning. In 2013, we reported how a Stage 3 activity was run in the pull-out gifted education programme: "*A neuroscience pull-out gifted program in a high school in Hong Kong: Connection of neurodegenerative diseases and traditional Chinese medicine in research-based learning*" (Suen et al. 2013).

In the present study, we develop five learning activities associated with live-cell imaging microscopy for the *Stage 2* of the Enrichment Model. These activities are evaluated based on
(i) the neuroscience knowledge acquired by students,
(ii) the practical skills acquired by students,
(iii) the ability of students to carry out scientific research independently,
(iv) student's interest towards science and
(v) student's interest in a career involving science.

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Learning activities associated with live-cell imaging microscopy:

(1) Mitotic cell division of SH-SY5Y cells

SH-SY5Y cells are neuroblastoma cells. They can carry out mitotic cell division. After sub-culture of SH-SY5Y cells, the time-lapse study can be set up to capture photos of dividing SH-SY5Y cells for 1-2 hours. The separation of chromosomes and cytoplasmic division can be easily observed.

The introduction of this activity aims at helping students visualize how a cell divides while most types of neurons cannot carry out cell division.

(2) Differentiation of SH-SY5Y cells

SH-SY5Y cells can be induced to differentiate into neuron-like cells by various agents. In our lessons, 10 μM of all-*trans* retinoic acid was applied to differentiate SH-SY5Y cells in DMEM supplemented with 2% fetal bovine serum (FBS). The time-lapse study can show the growth of neurites in SH-SY5Y cells after 3-4 days of the application of all-*trans* retinoic acid.

This activity aims at helping students visualize the outgrowth of projections in neurons, which is a special structural feature of neurons. Students can also identify morphological differences between differentiated and non-differentiated SH-SY5Y cells.

(3) Induction of cell death in SH-SY5Y cells

There are different methods and agents to induce cell death in SH-SY5Y cells. The methods and agents to be employed in inducing cell death depends on what kinds of cellular stresses, cell death pathways and future research focuses are studied. Some commonly used agents to easily induce cell death include H_2O_2, A23187 (Ca^{2+} ionophore) and thapsigargin (ER stress inducer). Yet, high school students may not be familiar with these agents. Heavy metals could also be applied to induce cell death in SH-SY5Y cells while a relatively higher concentrations of heavy metals should be used to cause visible changes in morphology in cell death within a week.

Treatment of SH-SY5Y cells with A23187 at 1 μM

Dividing SH-SY5Y cells

A set of activities to induce cell death helps students understand how cells respond to different stresses. More importantly, the progress of cell death can be visualized by time-lapse microscopy, helping students identify stepwise morphological changes during cell death.

(4) Changes in subcellular structures

There are commercially available fluorescent dyes to stain nucleus, mitochondria and endoplasmic reticulum. With these agents, the localization and morphological changes of the subcellular structures can be studied (depending on the quality of the microscope and camera) during different stages of cell death and under different cellular responses. Double-labeling of two or even three structures can be done technically to compare the concurrent changes of the subcellular structures.

The objective to observe changes in subcellular structures is to help students understand how a cell responds to a stimulus, in addition to basic changes in cellular morphology. Studying subcellular structures is an important step for students to develop research questions towards the observation of cell death.

(5) Expression of green fluorescent protein in SH-SY5Y cells

Transfection of cells is not new in researchers in biological sciences. There are different commercially available methods to insert a gene into a cell. To help students visualize whether a gene is inserted into a cell, green fluorescent protein (GFP) gene could be employed. Successfully transfected cells with GFP gene will express green fluorescence (relatively stronger fluorescence) which is easily observed by high school students.

Cells showing green fluorescence indicate that they uptake a foreign GFP gene. This learning activity helps students realize that genetic modification can be achieved to make changes (protein level) on cells. Moreover, students can understand the concept of gene expression.

Evaluation

Live-cell imaging microscopy helps students understand how neurites develop. Knowledge of cell biology is also strengthened. After carrying out a series of time-lapse studies on SH-SY5Y cells, students are confident to operate live-cell imaging system independently. Some students agree that they have more interest towards science and would like to be a scientist in future.

Teacher's Educational Research: Poster Presentation in the 47th Annual Meeting of Society for Neuroscience in Washington DC, USA in 2017

Evaluation of a pull-out neuroscience curriculum for high-school gifted students in science.

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We are a pioneer high school in Hong Kong to develop a neuroscience curriculum for scientifically gifted students (Suen et. al. 2010). It focuses on nurturing students' scientific literacy and interest through the Purdue Three-Stage Enrichment Model (Suen et. al. 2013). Research-based learning associated with neurodegenerative diseases is highlighted in this curriculum (Suen et. al. 2013). Students can apply brain cell culture (Suen et. al. 2008) and live-cell imaging microscopy in their research (Suen et. al. 2015). In the present report, we evaluate students' development on social skills, scientific literacy, knowledge in neuroscience and interest in science in this pull-out neuroscience curriculum. Both graduates and current students participating in this gifted program were interviewed. In addition, teacher's observation on students' daily performance in doing research and various learning tasks was applied to evaluate this pull-out neuroscience curriculum. Students' views of nature of science were also studied. Results showed that most of these students participating in neuroscience-related research for 0.5 to 4.0 years demonstrated increasing interest in science. They also indicated higher tendency to study science or science-related programs in universities. Yet, students' capacity on acquiring neuroscience knowledge can be promoted in this pull-out neuroscience curriculum. For example, students may not explore the anatomy of the nervous system of different species of organisms when their research projects are not related to these organisms. As students were required to collaborate with each other in doing research, they demonstrated improved social skills in terms of appreciation to others and self confidence. Taken together, this research-driven neuroscience curriculum can help scientifically gifted students to develop scientific literacy and interest.

Poster Presented in the 47th Annual Meeting of Society for Neuroscience in 2017

Evaluation of a Pull-out Neuroscience Curriculum for High-school Gifted Students in Science

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Introduction

Background:
Our school has developed a school-based neuroscience curriculum for scientifically gifted students since 2005 (Suen et. al. 2010). It is a pull-out program in which the gifted students have their neuroscience lessons outside regular school hours. These high-school students work in groups to do a research project and thus they work like a research student to learn neuroscience (Suen et. al. 2007). The design of the neuroscience learning activities is based on the Purdue Three-Stage Enrichment Model (Suen et. al. 2013a): understanding of basic neuroscience knowledge (stage 1), training on practical skills related to neuroscience experiments and research skills (stage 2) (Suen et. al. 2010 and Suen et. al. 2015) and development of a research project related to neuroscience (stage 3) (Suen et. al. 2013b).

2007	Research-based learning associated with an authentic topic can promote active learning in high school neuroscience lessons.
2008	Brain cell culture is an effective learning activity for high school students to acquire diverse knowledge and skills about neuroscience.
2010	Development of a school-based neuroscience curriculum in a high school in Hong Kong
2013a	An example of a high school in Hong Kong to develop a school-based neuroscience curriculum as a pull-out program for scientifically gifted students
2013b	A neuroscience pull-out gifted program in a high school in Hong Kong: Connection of neurodegenerative diseases and traditional Chinese medicine in research-based learning
2015	Evaluation of five learning activities associated with live-cell imaging microscopy in a high school neuroscience curriculum for scientifically gifted students

Objective: In the present study, we aim to evaluate this school-based neuroscience curriculum on the following areas (a) student's interest in science, (b) student's social skills, (c) student's knowledge in neuroscience and (d) student's scientific literacy in terms of nature of science.

Methodology

Seventeen students were observed during neuroscience lessons, interviewed and asked to do a questionnaire about their evaluation on the neuroscience curriculum and nature of science. Nine of these students had joined the neuroscience lessons for 0.5 to 1.0 year (Junior team). Another eight gifted students had participated in this neuroscience research program for 1.0 to 3.0 years (senior team).

Results

(a): Student's interest in science

(i) Interest towards science after joining the research-based neuroscience lessons

Junior team	Senior team
55.6% of students: increased	75.0% of students: increased
33.3% of students: unchanged	25.0% of students: unchanged
11.1% of students: decreased	0% of students: decreased

(ii) tendency to pursue a science-related degree (including engineering)

Junior team	Senior team
100% of students indicated that they would pursue a science-related degree.	100% of students indicated that they would pursue a science-related degree.

(iii) Interest to be a neuroscientist

Junior team	Senior team
62.5% of students indicated that they wanted to be a neuroscientist.	50% of students indicated that they wanted to be a neuroscientist.

(b) Student's social skills

By teacher's observation, all students showed improvement on social skills in terms of appreciation to others and self confidence. It was seen that conflicts would occur when students cannot agree to others' ideas on research methods and result analysis. The increased occurrence of conflicts might create opportunities for students to learn social skills.

(c) Student's knowledge in neuroscience

Students' self-assessment on the need to learn different neuroscience topics was done (*1: most need; 14 least need*).

Junior team	Senior team
(1) Memory	(1) Memory
(2) Emotion	(2) Sleep
(3) Sleep	(3) Emotion
Brain development	(4) Pain
(5) Pain	(5) Brain development
Taste and smell	Brain anatomy
(7) Functioning of neurons	(7) Taste and smell
(8) Structure of neurons	(8) Functioning of neurons
Brain anatomy	Structure of neurons
Neurodegenerative diseases	(10) Neurodegenerative diseases
(11) Vision	Neuronal death
Methods of scientific research	(12) Vision
(13) Neuronal death	(13) Methods of scientific research
(14) Technique of cell culture	(14) Technique of cell culture

(d) Nature of Science

Students were asked to do a 48-question questionnaire (5-Likert-type scale) of Nature of Scientific Knowledge Scale (NSKS) in the Chinese version (CNSKS).

Factor in CNSKS	Junior team (Mean score (S.D.))	Senior team (Mean score (S.D.))
Amoral	25.8 (3.7)	26.5 (2.4)
Creative	14.8 (4.1)	16.3 (4.4)
Developmental *	24.2 (3.5)	27.9 (3.3)
Parsimonious *	21.8 (1.8)	27.8 (3.7)
Testable *	21.7 (1.9)	24.1 (0.8)
Unified *	25.6 (3.4)	30.3 (5.2)

** : significant difference in comparison of the Junior team and Senior team in ANOVA test (p<0.05), followed by Turkey's post-hoc analysis*

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Student's sharing

What are nurturing my interest in Science?

WONG Chun Hei

(S.7 Graduate in 2011; Student of Doctor of Philosophy in The University of Hong Kong)

I am a 2010-2011 graduate from PLK Laws Foundation College (LFC). I am currently a Ph.D. candidate in the Department of Chemistry in The University of Hong Kong. Looking back to my study path, the research experience in the Neuroscience Club in LFC inspires me to pursue my research career today.

The experience when I was a junior form student in the Neuroscience Club allowed me to get a little taste of how a research study could be conducted. In the presence of many advanced facilities in the DiagCor Biotechnology Laboratory in LFC, I could carry out the culture of neuronal cells from the brain of newborn rats, which was a "university-level" experiment. I still remember the first time I extracted the brain tissue from the newborn rats under the supervision of Dr. Suen Ka Chun. It was scary at first but your skills would be more sophisticated after practice for many times.

There were lots of memories in the Neuroscience Club. Other than techniques, it is the way of thinking that affects me the most. The motivation of doing research is to explore the world of 'Unknown'. Dr. Suen inspired me to look into the relationship between our observation and factual outcome. Our research team comprising seven S.2 students conducted an experiment to investigate the relationship between sleep and memory. We learnt to use some standard scientific methods to test different types of memories such as short-term memory. More importantly, we had an invaluable chance to present our research data in an international scientific conference in the United States of America in 2006 where neuroscientists from different universities published their latest findings. Indeed, our small-scale research study might sound negligible to these scientists and professors, but it was really encouraging that some of them would spend their valuable time to read our research paper and give us comments on our study. When we walked around the conference hall, we were astonished that the poster presentations from other scientists were well beyond our level of scope. Nevertheless, their ways of assumptions and predictions out of the observations were an unforgettable lesson to us. And now, though I am working in a different field of study, I am still applying what I have learnt in the Neuroscience Club to explore the research gap in my research field, which is the world of 'Unknown' in Chemistry.

Wong Chun Hei joined a summer training programme in Department of Anatomy, Faculty of Medicine, The University of Hong Kong in August 2005.

Student's sharing

Why do I love Science?

CHAN Sau Tsun (4J Student)

Have you ever wondered what enables us to live, or we may become immortal in the future? I am sure that everyone of you must have asked these questions before. Indeed, the reason why you would ask these questions is the same as the reason why we learn Science. That's all about curiosity.

Curiosity is definitely an important factor encouraging me to learn Science. Through Science, I can explore the world and get to know more about how organs, tissues and cells work. But if you ask what is really nurturing my interest in learning Science, I would say curiosity is just what motivates me. What is actually nurturing me is the education in my secondary school.

When I first entered PLK Laws Foundation College (LFC), I noticed that there was a subject called "Biotechnology" which I had never seen in other schools. I then had my first Biotechnology lesson. When I heard about Dolly, the cloned sheep, I was shocked because I couldn't imagine how an organism could be cloned. There is no doubt that this school-based subject can broaden my horizons and arouse my curiosity towards Science.

Last year, I joined Neuroscience Club. My teammates and I did a research about what substances can protect neurons against toxic chemicals. We used a plant called *Mentha Citrata* and brain cells called SH-SY5Y for experiments. In the research process, we learned the reasons for using different chemicals in the experiment. For example, why was hydrogen peroxide used in the experiment? Before joining the Neuroscience Club, I think I can only answer that hydrogen peroxide can kill cells. Yet, after doing many experiments in the Neuroscience Club, I can think about the reason behind the reason, which is the underlying principle of the toxicity of hydrogen peroxide in brain cells.

I like doing research as there is a lot of interest behind each experiment. Science is truly fascinating. It's not just a subject, but our life. Everything in our life is related to Science, from eating to studying, and everything is nurturing my interest towards Science. When you try to observe the details in everyday life, you will be curious about how they work and be enchanted with Science.

CHAN Sau Tsun is working on a cell culture experiment in a Class II Biological Safety Cabinet.

Student's sharing

I am proud of being the Chairman of the Neuroscience Club

MA Ho Him

(S.6 Graduate in 2016; Student of Bachelor of Science in The University of Hong Kong)

As a Chairman in the neuroscience research team in PLK Laws Foundation College (LFC), I am proud of being a student who can give presentations in an international conference of Society for Neuroscience held in the United States in 2013 and 2015 respectively. I have learnt how to be a scientist who can ask questions and is able to study the questions with scientific methods.

There was a lot of work before attending the international conference. For example, our research team had done a series of experiments during lunch time and after school for about two years. We then analyzed the experimental data and re-designed another set of experiments targeting a new question raised from the data. We also needed to write articles to present our research findings which should be presented systemically and scientifically. As a leader in the research team, I am pleased to have opportunities to organize different experiments, giving me valuable experience in leading a research team.

In LFC, we have a well-equipped biotechnology laboratory. I love it as I have unforgettable memories in this laboratory. I still remember the moments of culturing neurons and treating them with Chinese Medicine and different toxins in the Biological Safety Cabinet in our DiagCor Biotechnology Laboratory. I would like to give sincere thanks to Principal and Science teachers for their continuous support given to us so that we can do some university-level experiments in a secondary school. Without their encouragement and advice, we cannot present our research findings in a top scientific conference in the United States.

I am looking forward to seeing more LFC students to do scientific research and present their findings in different conferences.

MA Ho Him (middle) and his team are going to give a presentation titled "Research-Based Learning in Science Education".

Student's sharing

We can do brain cell culture in a secondary school.

CHAU Wai Hin

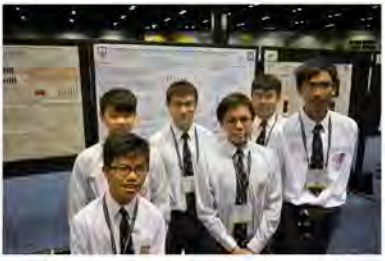
(S.6 Graduate in 2017; Student of Bachelor of Engineering in The University of Hong Kong)

You may have experience in keeping pets. Do you have any experience in culturing brain cells? In brain cell culture, the cells are isolated from the brain and then kept in a special condition. These brain cells outside the brain can grow in a man-made chamber where suitable temperature and nutrients have to be provided. We can do brain cell culture in PLK Laws Foundation College.

In Neuroscience Club, there is a group of young scientists working on the brain. I was one of the members of Neuroscience Club when I was in the levels of S.5 and S.6. Students in Neuroscience Club do scientific research on the brain. Yet, it is difficult for us to have many rat brains for research. Instead, we can have many cultured brain cells for experiments. You may have a question on how we can get the brain cells. Do they come from a human? We use SH-SY5Y cells which are human neuroblastoma cells. Simply, SH-SY5Y cells are cancer cells which can grow continuously. Some people may think that it is dangerous to culture SH-SY5Y cells. Yet, cancer is a non-infectious disease and SH-SY5Y cells cannot develop cancer in a normal human. Moreover, we have different safety procedures to handle cell culture to ensure that there is no risk for disease transmission.

How can we culture SH-SY5Y cells? To keep cells alive and support them to grow, culture medium containing different nutrients is needed. The human brain cells should also be kept at 37°C, the optimum temperature for enzymes in human brain cells. In our DiagCor Biotechnology Laboratory, there are two Biological Safety Cabinets which can provide a sterile working station for us to do cell culture experiments. Moreover, these cabinets form a barrier to protect us against experimental agents such as toxins and SH-SY5Y cells.

As a secondary school student, it is a great chance for me to do cell culture experiments in our school laboratory. The experience that I have got from cell culture helps me understand how scientists work on cell biology.



CHAU Wai Hin (front left) attended a neuroscience conference in the United States in 2015.

Student's sharing

What can I do with the live-cell imaging system?

SHI Pok Lai

(S.6 Graduate in 2017; Student of Bachelor of Engineering in The Hong Kong University of Science and Technology)

In 2013, a live-cell imaging system was purchased and installed in our school's DiagCor Biotechnology Laboratory.

What is the live-cell imaging system? It is actually a very powerful microscopy system. It allows scientists to take photos and videos on live cells under a microscope. As you know, in cell culture experiments, some advanced facilities are needed. For example, an incubator which can provide a stable temperature is required. In the past, it was not an easy task for scientists to capture images for several days continuously under a microscope. In our DiagCor Biotechnology Laboratory, we have this live-cell imaging system for studying cells overnight.

In the Neuroscience Club, students can do experiments on brain cells. Sometimes, we set up an experiment overnight and then used the live-cell imaging system to record the morphological changes of the brain cells. As the whole system is connected to a computer, we can run pre-loaded programmes to automatically capture microscopic images with desired time lapse. Therefore, we can observe different changes of the brain cells at different moments. This live-cell imaging system is also equipped with special inputs of light. It can be used to detect the condition of different organelles when specific dyes are used. For instance, we can study the changes of endoplasmic reticula and mitochondria in brain cells when they are treated with a toxic chemical. Therefore, this live-cell imaging system plays an important role in our research.

This live-cell imaging system starts my scientific career in a secondary school and trains me to be a future scientist and engineer.

SHI Pok Lai (right) is introducing the technology behind the live-cell imaging system in front of parents.

Student's sharing

Why do I love scientific research?

HAU Pak Chuen

(S.6 Graduate in 2017; Student of Bachelor of Engineering in The University of Hong Kong)

When I was a child, I was attracted by Science very much. My passion towards Science was further promoted by the Science lessons in PLK Luk Hing Too Primary School (LHT). My interest to do scientific research was then initiated in PLK Laws Foundation College (LFC).

In my primary school life, the Science lessons gave me a lot of chances to study the Science world. I still remember many interesting experiments that I carried out in LHT. These experiments included "Elephant Toothpaste" and "Wooden Airplane". While the concepts behind these experiments were not difficult, my curiosity in Science was aroused. The Science curriculum in the primary school helped me build up strong interest as well as good knowledge foundation in Science.

When I entered LFC, I was pleased to join a scientific research team called Neuroscience Club. In the Neuroscience Club, I did a variety of researches on brain cells. This experience further nurtures my interest towards Science. I enjoyed designing and conducting experiments on brain cells as I can understand more about the brain. I enjoyed the time in the DiagCor Biotechnology Laboratory as I could be a real scientist to study how to rescue brain cells from neurodegenerative diseases. During the three-year experience in the Neuroscience Club, I have found that "Science is somehow a way to show our humanity", like making possible ways to cure the incurable diseases. Therefore, I love scientific research in terms of interest and mission. In future, I hope I can become a scientist to apply scientific knowledge to improve human life.

HAU Pak Chuen is doing an experiment on brain cells.

學生分享

從學校神經科學學會的研究，看中學生做科學研究的得著

周柏臻

（2016年中六畢業生，現為香港大學科學院學士學生）

記得當初在中二的時候，參加了一個小型的科學比賽，雖然入圍但卻沒有得獎。這個就是我對科學產生興趣的起點。在這次比賽之後，我就被我校的孫嘉俊博士邀請進入神經科學學會，並嘗試人生中第一次「做研究」。以當時中二、中三的科學知識來應付「研究」這個廣闊的領域其實有一定的難度，但有著孫博士的引導和學校的一些先進儀器，我開始建構出「研究」的框架：一個目標、多個方法以及一個假設。

隨著時間的過去，我和同學的研究開始成型，從一開始零零星星的想法逐漸合併為一個大方向，我們也以這些研究參加過在美國舉辦的一個國際神經科學會議，然後在2015年以「柑桔核提取物的腦神經保護作用」參加了全國青少年科技創新大賽。這個比賽跟參加美國會議的形式類似，也是以海報來介紹自己的研究，但美國會議是和世界不同科學家交流研究心得，而全國賽則是回答評判的一些疑問。在美國時我們已經受過提問接踵而來的情況，所以在全國賽也有一定的心理準備，可是評判的疑問仍在原先的思維外，這讓我更加明白到所謂的「研究」其實就是去尋找未經探究的事物，一個研究的結果可能就是下一個研究的起點，就如我們的題目：儘管柑桔核是有腦神經的保護作用，但是到底哪一種物質在起作用？

經過幾天的評審和我們的努力，我們很幸運地獲得了十佳科技創意之星和一等獎。雖說能夠獲得獎項對我們未來升讀大學有一定的幫助，但更令我滿足的是這是對當初決定開始做科學研究的我的一個肯定。做一個科學研究對我來說所需要的不單是相關的知識和儀器，更是同時兼顧學業和進行研究的毅力。平常的一個實驗如加入不同提取物樣本到細胞培養碟就已經用了我們數小時的時間，所以實驗只能在午飯時間或放學後進行，回到家時還要把功課完成，對我來說實在是一大考驗。

以我一個小小的中學生做科學研究時所經歷的事，我認為這能使人訂立一個清晰的目標，並向該目標前進，是人生的一個縮影。同時，也為未來的我鋪好前進的第一級石階。

周柏臻(中)及洪英傑(右)於「第三十屆全國青少年科技創新大賽」中獲得「十佳科技創意之星」、「青少年科技創意作品一等獎」、「香港賽馬會創新科技獎 最佳獎」。

Development of a space science project to foster students to engage in inquiry-based learning

M. WONG Yeung, Head, Department of Physics

Inquiry-based learning requires students to gain the authority to learn by themselves, to think critically to solve real-life problems. In LFC, in order to help students implement inquiry-based learning in real-life contexts, students are encouraged to participate a variety of competitions so that they are not only bound by the HKDSE curriculum, they can also apply what they learnt in the lessons and realize their ideas in science by designing various experiments. In November, 2014, the Home Affairs Bureau of the Hong Kong Special Administrative Region Government and China Manned Space Agency jointly organized the space science experiment design competition for Hong Kong secondary school students. The competition aims to enhance local secondary students' understanding of China's advances in aerospace science and foster a culture of innovation in Hong Kong.

On the Earth, many phenomena and laws of physics can be well explained with the concepts of "fields", such as gravitational field, electric and magnetic fields. When a space laboratory moves in a very high orbital speed around the Earth in which the gravitational force on the laboratory provides the centripetal force required for its circular motion, a microgravity environment is created inside the laboratory. In this environment, physical laws like conservation of energy and conservation of momentum may have variations from that observed on the Earth. Though youths have ideas and motivation to design experiments to verify whether these physical laws are still correct in a microgravity environment, they tend to abandon such move as it is unbelievable there is someone who will help to bring an experiment designed by secondary students on board of a space rocket. Thanks for the advancement of mainland space science technology, the chinese space laboratory, Tiangong-2, was launched in 15th September, 2016. With the selfless help from Chinese astronauts, the winning projects of the space science competition can be demonstrated historically in Tiangong-2 and students' dream of performing their own experiments in space become achievable.

In November, 2014, four LFC secondary 4 students, Hau Pak Chuen, Ho Long Fung Marcus, Ma Tsz Kiu, and Shi Pok Lai , who were former LHT primary students educated under a through-train science curriculum from LHT to LFC, show great interests in science. Once they were notified of the space science competition, they eagerly agreed to participate in the competition and actively thought of suitable projects to be proposed. They were aspired to have opportunities that their designed experiments can be carried out under a microgravity environment. In designing the project title, just like scientists who always encounter difficulties in drafting a project title for investigation, they needed to think of measures to overcome the adverse environment in the microgravity environment like fixing the apparatus firmly in certain positions, reducing the mass of the apparatus so as to reduce cost of launching and any potential risks like sharp cutting edges or catching fire. The following article from one of the designers of the project, Hau Pak Chuen, shares on how the LFC students got the innovation of designing the project title for the space science experiment.

Space Science Experiment Design Competition for Hong Kong Secondary School Students

Student: HAU Pak Chuen
HO Long Fung Marcus
MA Tsz Kiu
SHI Pok Lai

Teacher: Mr. WONG Yeung

Title of the experiment: Chaotic or Predictable? Oscillation of a double pendulum under weightlessness condition

Introduction

If a double pendulum is performed on the Earth, under the action of the gravity, the motion of the double pendulum performs a chaotic oscillation. One of the characteristics of chaotic oscillation is that it depends heavily on the initial conditions of the set-up such as the initial positions of the pendulum, its initial speed, initial direction of motion, the masses of the attached pendulum bob, etc. The second characteristic is that although the differences between the initial conditions are minor, after the beginning of the experiment, the differences would accumulate and become more significant in the subsequent motions. It is believed that the force of gravity is one of the factors which cause the chaotic motion of the double pendulum. In the space station, the normal reaction becomes nearly zero, so the effect of the force of gravity is reduced greatly. If the force of gravity is eliminated, it is expected that the motion of the double pendulum become more predictable in a way that its motion can be formulated with some simple equations of motion, comprising of factors such as time, length and mass which are the basic physical quantities of motion.

Aim

When pivoting a rod in an environment on Earth, it will swing due to the moment given by the gravity. This is a simple pendulum, which moves in a simple harmonic motion that we can calculate its period with the length L and the gravitational acceleration g. When we connect another simple pendulum on the tail of the original pendulum, a double pendulum is formed. However, differ from the simple pendulum, the double pendulum has a chaotic motion and it moves in an unpredictable way that we cannot predict its behavior on Earth. In double pendulum, a little difference in its variables will be magnified and create a motion not able to be predicted. Double pendulum is commonly used as a model to learn chaos theory in physics. Although it is commonly used on earth, we found that there is no double pendulum experiment performed in space. So we set up an experiment in space to investigate how double pendulum will behave in microgravity environment. We would like to investigate whether gravity is a factor which affects the Lyapunov exponent which causes a motion to become chaotic.

Significance of the project

Chaos is dependent heavily on initial conditions, which means tiny initial separations,

$\Delta x(t_0)$, between nearby conditions are amplified exponentially in time t, (Shinbrot, T., Grebogi, C., Wisdom, J., & Yorke, J. A. ,1992)

$$\Delta x(t) \approx \Delta x(t_0) e^{\lambda t},$$

where $\Delta x(t)$ is the separation between nearby trajectories and λ is some positive constant which is known as Lyapunov exponent. It is expected that the constant depends on the state of the system, i.e. the positions, speeds (Shinbrot, T., Grebogi, C., Wisdom, J., & Yorke, J. A. ,1992). The aim of our experiment is to investigate whether the constant in double pendulum also depends on gravitational acceleration.

By using Taylor's expansion,

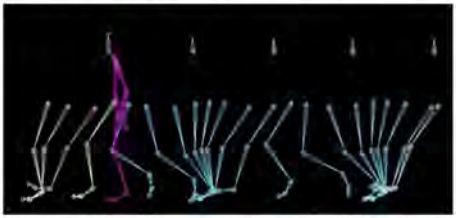
$$\Delta x(t) \approx \Delta x(t_0)(1 + \lambda t + \frac{(\lambda t)^2}{2!} + \frac{(\lambda t)^3}{3!} + ...)$$

In our experiment, we mainly focus on the effect of gravity on the motion of the double pendulum. It is believed that under a microgravity environment, where g, the gravitational constant is very small, the above relation would become a linear relation

$$\Delta x(t) \approx \Delta x(t_0)(1 + \lambda t)$$

so that tiny initial separations would only increase linearly with time and the motion afterwards would become predicable.

A double pendulum involves two rotating bodies which are the upper and the lower simple pendulums. Similarly, human legs include upper leg and lower leg in which the knees act as junctions. Therefore, it is expected that human walking, and the movements of our elbows and arms, are accomplished with the strategy of double pendulum.



(Source: http://en.wikipedia.org/wiki/Walking)

In our project, through investigating the motion of double pendulum within the space station, the mechanism of walking and the swinging motion of human arms in microgravity environment can be investigated. The results can be used for designing the legs and arms for a space robot which can help perform experiments in a microgravity environment, especially those not suitable for astronauts(Featherstone, 2013).

Design of the experiment

The motion of the double pendulum on Earth is affected by the gravitational force due to the Earth's gravity. But the gravitational force in microgravity environment is so weak that cannot provide the double pendulum with enough net force to swing. Therefore we need to provide a net force by applying an external force to start the motion of the double pendulum. As we need to ensure force given to the double pendulum in each trial is the same, we are using simple machine crafted by spring to give double pendulum the same initial velocity to start its

motion. Two plastic rods with approximately uniform density are used to make the double pendulum. The materials of plastics are chosen so as to reduce the weight of the set-up and also reduce the force needed to start the motion of the double pendulum in space. They were joined together end by end with the screw and ball bearings so that the plastic rods can rotate freely with very little friction.

Apparatus

i) Components in making the double pendulum:

(a) 2 identical plastic rods of two different colours (white and blue) with holes on them

Details of the rods:

Mass: 9.4 g for each rod

Diameter of each hole: ~ 6 mm

Length: total of 11 cm, each rod with 7 cm

(b) ball bearings of 6 mm diameter

Function: installed on the junctions of the two rods in order to reduce the friction of the junctions when the rods are rotating.

(c) Screw nuts

Function: for connecting the plastic rods with the ball bearings in the holes

(d) Holes on the plastic rods for making the pendulum

Function: the length of each pendulum can be adjusted

ii) A two-heads clamp is used for hanging the double pendulum to a table edge in the space station.

Mass: 47.4g

iii) Two identical spring-loaded launcher

- It is modified with a spring-loaded pen in order to produce an impact force on the double pendulum.

iv) Dimensions of the whole set-up (the double pendulum, the two-head clamp and the spring-loaded launcher)

5 cm × 11 cm × 14 cm

Photos of the set-up:

Front view of the double pendulum

Side view of the double pendulum

Spring-loaded launcher

Procedures

There are two parts in the experiment. The first part is to observe the motions of the double pendulum in different initial conditions on Earth, which include different initial positions of releasing it from rest and different initial velocities given by the applied forces. The motions of the double pendulum on Earth would be compared with that in the microgravity environment. It is expected that under the action of gravity on the earth, minor different initial conditions will cause a large difference in the patterns of oscillations with time and become chaotic and non-predicable. In microgravity, the minor initial differences would only vary linearly with time and the motions afterwards would become predicable.

The second part is to exert an impact force on the middle of the double pendulum, and measure the time taken for the double pendulum to become rest. The stopping times for the oscillation on Earth and that in the microgravity environment would also be compared.

Experimental set-up:

(i) Connect two plastic rods together loosely with the screw nuts at the junction A to form a double pendulum.

(ii) As shown in the following diagram, hang the double pendulum on a supporting point O which is nearly frictionless.

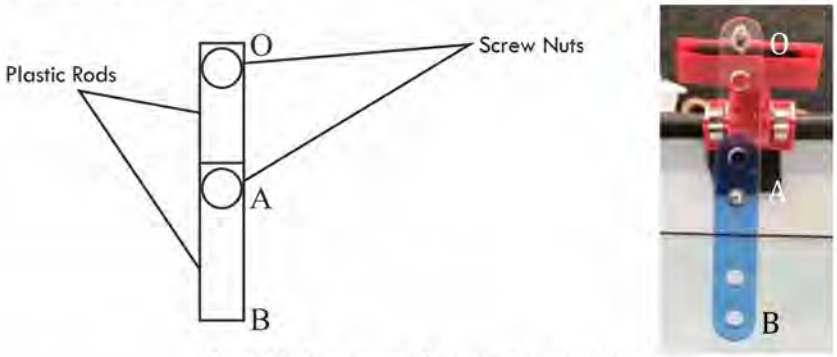


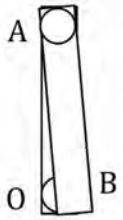
Figure 0: The set-up of the double pendulum

Firstly, the two parts of the experiment are performed on the Earth.
The first part of the experiment – Comparing the motions of double pendulum in different initial conditions on Earth and that under microgravity environment to investigate whether gravity is a factor that increases the minor different initial conditions to cause chaotic motion:

1st set-up:

The double pendulum is released from rest at different initial angles as shown in Figure 1a and 1b respectively.

Trial A:



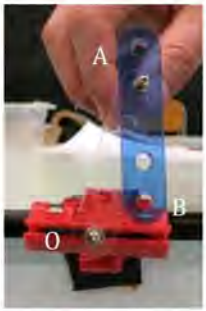
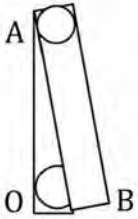


Figure 1a

Trial B:



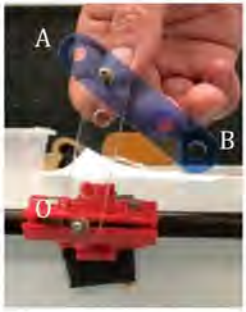


Figure 1b

Observed result:

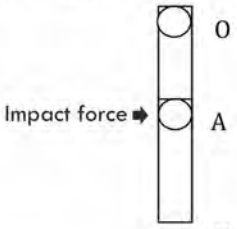
As the swinging motions of the two pendulums are so fast, in order to compare the differences in the patterns of their motions, their motions are captured by high-speed video cameras so that they can be played in slow motion. As time proceeds, the difference in motions of the two slightly different initial angles for the double pendulum increases such that the patterns of the oscillations are different afterwards. It is thought that it is because of gravity which increases the initial small separation with time.

2nd set-up:

The double pendulum is firstly hanged at the junction O, which is free to rotate about O and A. Then the junction A is projected with an initial velocity (Figure 2a).

Trial A:

To ensure the impact force given to the pendulum in each trial is the same, a spring launcher is used to give the impact force. Each time the spring is compressed for the same length in order to produce the same impact force.



Impact force by spring launcher ➡

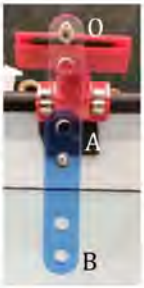


Figure 2a

Trial B:

Repeat the procedures for the 2nd set-up with slightly different initial separation between the spring launcher and the point A of the double pendulum. It is expected that the magnitude of the impact force on the double pendulum is slightly different from that in trial A so that the double pendulum starts swinging with slightly different initial velocity.

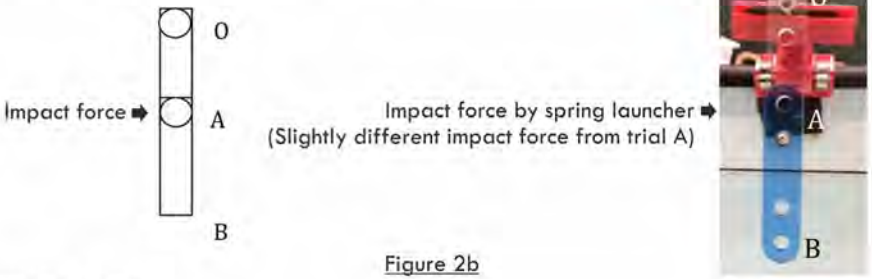


Figure 2b

Observed result:

Initially, the motions of the two pendulums are similar. As time proceeds, the difference in the patterns of the oscillations in the two trials increases afterwards. It is thought that it is because of gravity which affects and increases the small differences in the initial velocities of the two trials in the 2nd set-up.

3rd set-up:

The double pendulum is firstly hanged at the junction O, which is free to rotate about O. Then the junction B is projected with an initial velocity (Figure 3a).

Trial A:

The point B is projected with an initial velocity (Figure 3a) with the spring-loaded launcher.

Figure 3a

Trial B:

Repeat the procedures for the 3rd set-up with slightly different initial separation between the spring launcher and the point B of the double pendulum. It is expected that the magnitude of the impact force on the double pendulum is slightly different from that in trial A.

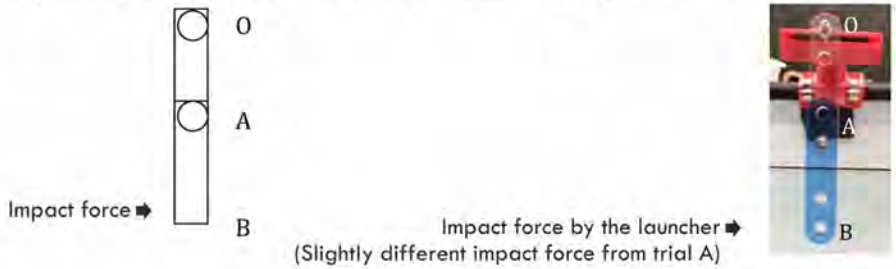


Figure 3b

Observed result:

Just like the 2nd set-up, it is expected that the minor different initial velocities of point B because of the minor different impact forces would result a larger differences in the patterns of oscillations after some time. It is also expected it is the gravity which enlarges the initial minor differences.

4th set-up:

The double pendulum is firstly hanged at the junction O, which is free to rotate about O. Then both junctions A and B are projected with nearly the same initial velocity at the same time (Figure 4).

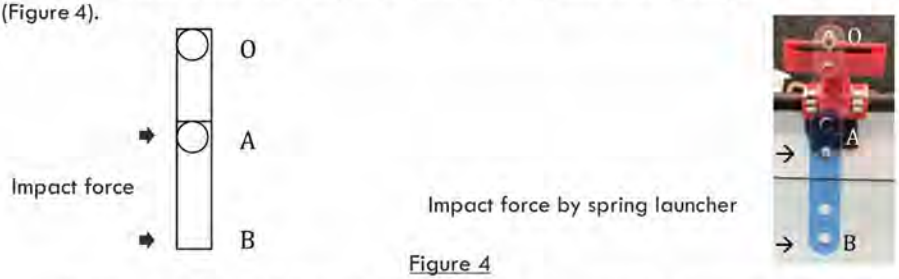


Figure 4

To ensure that the points A and B are projected with the same initial velocities, the impact forces on points A and B should be the same. This is done by two identical launchers with the same initial separations from points A and B respectively. The two launchers should hit the two points at nearly the same time instants.

Observed result:

The points A and B are projected nearly with the same initial velocities, the double pendulum rotates as a single pendulum with points O, A and B in nearly a straight line initially. It is expected that there does have very slight differences in the initial velocities of points A and B due to sorts of random errors. It is observed that after some time, the double pendulum's motion becomes chaotic and points O, A and B do not lie on the same straight line. It is because the gravity which increases the minor differences in the initial velocities in points A and B. This makes such minor differences finally observable after some time.

The second part of the experiment:

The 2nd set-up in the first part is used to measure the time taken for the double pendulum to become at rest.

A stopwatch is used to measure the corresponding time (Figure 5).

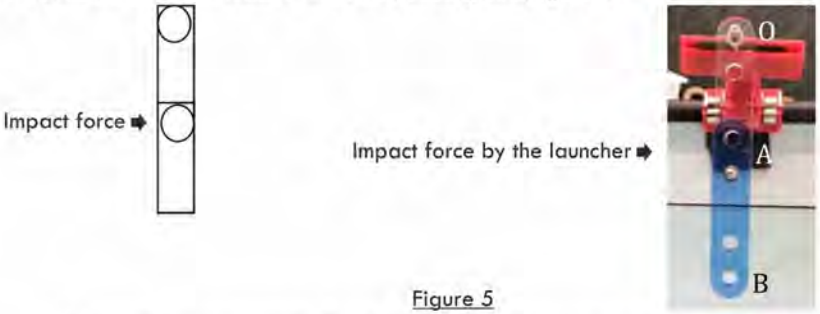


Figure 5

Repeat the experiment for five times to find the average result of the stopping time. The results of the stopping time would be recorded in the following table:

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Stopping time / s					

The average result is $\frac{\text{sum of the stopping times of all trials}}{5}$

Finally, repeat the first and the second part of the experiment in the microgravity environment in the space station. The expected results and discussions are as follows.

Expected results and Discussion

The first part of the experiment:

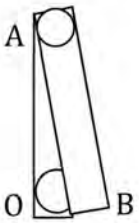
1st set-up:

The double pendulum is released from rest at different initial angles as shown in Figure 6a and 6b respectively.

Trial A:

Figure 6a

Trial B:



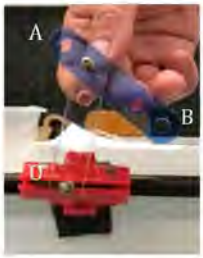


Figure 6b

Observed result:

It is expected that in the two trials. The double pendulum in the two trials remains at rest due to inertia. The trial B keeps a minor small different initial angle from trial A in which the minor difference does not increase with time. It is because there is no gravity which increases the initial minor differences in the initial positions. The motions afterwards depend only on the initial positions and become predicable.

2nd set-up:

Trial A:

The upper part of the pendulum OA is predicted to be rotating anticlockwise about O, while the bottom part of the pendulum AB will rotate clockwise about A, in which the rotations are in complete revolutions. The rotation period of OA is expected to be nearly the same with that of AB.

The expected motions of the double pendulum at different moment are shown below (Figure 7).

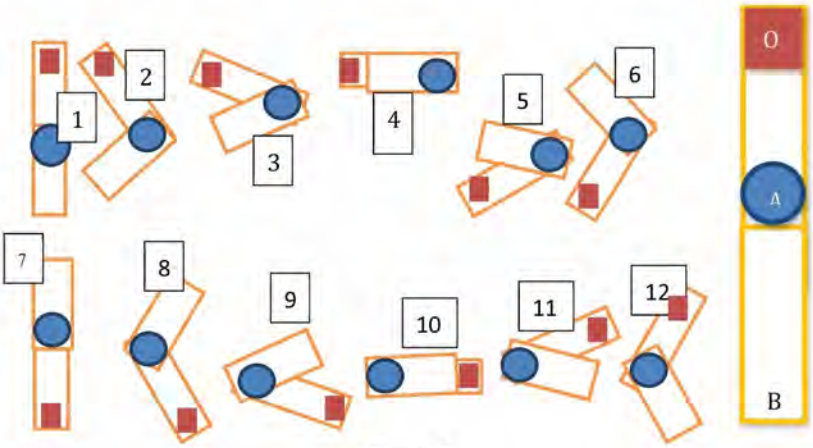


Figure 7

Explanations: As the impact force is acted at A, there is an anticlockwise moment about O, so the rod OA is expected to rotate anticlockwise. For the rod AB, as the point B tends to remain at rest

due to inertia, but the impact force at A is applied to the right, causing AB to move clockwise about A. These rotations are expected to rotate completely because there is only a small gravitational force in the space station to restore the double pendulum to the initial resting position.

Trial B:

Repeat the procedures for the 2nd set-up with slightly different initial separation between the spring launcher and the point A of the double pendulum. It is expected that the magnitude of the impact force on the double pendulum is slightly different from that in trial A.

Expected result:

Under a microgravity environment, the motion in trail B is similar to that in trail A. There is little gravity which increases the initial minor differences in velocities. So, the motion in trail B only varies linearly with trail A according to equation:

$$\Delta x(t) \approx \Delta x(t_0)(1+\lambda t)$$

So, after some time, the pattern of motion in trial B is very like that of trail A and the effect of impact force at A becomes predicable.

3rd set-up:

Both rods OA and rod AB are expected to rotate anticlockwise. Point B may have a larger tangential velocity than point A (Figure 8).

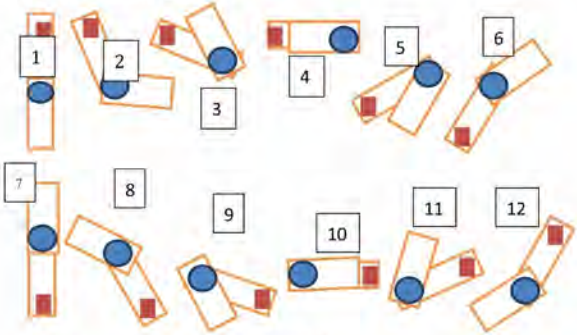


Figure 8

Explanations: As there is an applied force on point B, there will be an anticlockwise moment. Since rod AB receives an impact force in tangential direction, AB has a net force to acclerate tangentially. By conservation of momentum, point B will have a larger velocity than the common velocity of point A which involves the junction of two plastic rods. The time required for the rod AB to complete one revoluion is shorter than that of the rod OA.

Trial B:

Repeat the procedures for the 3rd set-up with slightly different initial separation between the spring launcher and the point B of the double pendulum. It is expected that the

magnitude of the impact force on the double pendulum is slightly different from that in trial A. Point B then moves with slightly different initial velocity with the previous trial.

Expected result:

Just like the 2nd set-up, it is expected that the minor different initial velocities of point B would only cause the motion of the 3rd set-up to vary linearly with the trial A. So, the motion in trial B is similar to that in trial A with little differences in the patterns of motion as time proceeds. It is because there is little gravity to increase the initial minor differences in the initial projected velocities in point B.

4th set-up:

The whole pendulum is expected to rotate anticlockwise about O as a single pendulum (Figure 9).

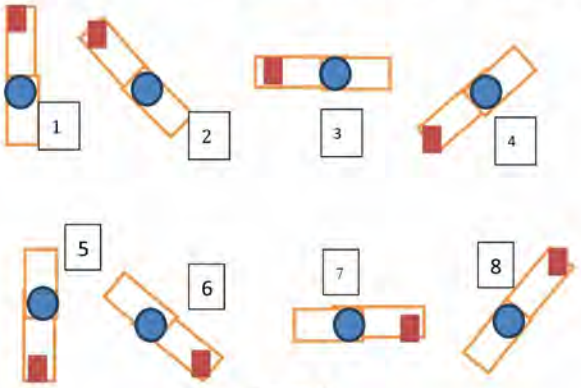


Figure 9

Explanations: As the applied forces acting on points A and B are the nearly the same and the mass of the point A is double that of point B, the times of impact for points A and B are nearly the same.

At point B, by impact force $F = \frac{mv - mu}{t}$

$$F = \frac{mv_B - 0}{t}$$

$$v_B = \frac{Ft}{m}$$

$$\omega_B = \frac{Ft}{m(r)},$$

where r is the length of the whole pendulum and m is the mass of each plastic rod.

At point A, $$F = \frac{mv - mu}{t}$$

$$F = \frac{(2m)v - 0}{t}$$

$$F = \frac{(2m)(\frac{r}{2}\omega_A) - 0}{t}$$

$$\omega_A = \frac{Ft}{m(r)} = \omega_B$$

so the angular velocities of points A and B about O will be the same and the double pendulum performs a uniform circular motion with the centre at O.

In space station, there is little gravity which increases the minor differences in the initial velocities of points A and B. So, the double pendulum keeps a long time rotating as a whole in circular motion with the points O, A and B along a straight line. The motion therefore becomes predicable.

The second part of the experiment:

The 2 nd set-up in the first part is used to measure the time taken for the double pendulum to become at rest in space. The procedure for measuring time taken is also repeated for five times so as to obtain an average result.

Expected result:

The time taken for the pendulum to swing in space is predicted to be longer than that on Earth. At the same time, the stopping time in the former is predicted to be longer than that in the latter.

Explanations:

As there is a very small gravitational force in the space station, the normal reaction on the axis of rotation of the pendulum will be smaller. The double pendulum is stopped due to the opposing torque produced by friction between the pendulum and the pivot at the junctions. Maximum friction is proportional to the normal reaction. Smaller normal reaction results in smaller maximum friction.

By calculating the maximum friction, which is Coefficient of friction × Normal reaction, there will be a smaller opposing torque on the rotational motion, resulting a longer stopping time.

Conclusion

On Earth, double pendulum motion is chaotic. It is expected that gravity is a factor that increases the slightly different initial conditions to make motion unpredictable afterwards. By comparing those motions of double pendulum on Earth and that under a microgravity environment in the space station, the factor whether gravity has a significant effect on the unpredictable way of motion of a double pendulum can be investigated. It is expected that by reducing the gravity on the motion of double pendulum in the space station, the Lyapunov exponent would be reduced, so that the initial separations become a linear relationship with time. This makes the motion of double pendulum become predicable in the microgravity environment. By the way, reduction in gravity also causes a reduction in maximum friction between the joints. The stopping time for each double pendulum motion is longer than that performed on Earth.

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學生分享

實驗設計的意念

侯柏全

（2017年畢業生，現於港大工程學系就讀）

經常有人問我，是如何將雙擺和太空搭載實驗比賽聯繫在一起的，我大多數都會回答，是在參考天宮一號和美國太空總署的實驗後，經改良所創造出來的。無可否認，其他人的論文在這個實驗比賽中的確發揮了很大的功用。但事實上，我認為真正令我構思到這個題目的原因是我對科學的好奇。

從小開始我就十分熱愛科學，我想知道世界上所有未知的事情，大多數人在小時候對科學的熱情就已經冷卻。這也難怪，畢竟香港主流文化都不看重科學，小時候沒有接觸的機會，自然就從腦海中淡忘。幸好，從小父母鼓勵我多接觸科學，令我沒有將時間全放在鋼琴八級，多國語言「有意義」的事情上，而是多留意世界，探索我未知的事情。

此外，小學的科學課程更加增添了我對科學的興趣。其實所謂科學不一定要讀到相對論等高深課題，留意環境的轉變，例如水的變化，普通力學等日常生活經常接觸到的事情。已經可以提升對科學的好奇，小學的科學課提供了大量以實驗為本的課題，在做實驗時再思考實驗背後的原理。正因如此我從小就培養了用科學思維去思考的習慣—科學的構思是建基於創意的，首先大膽假設，再小心求證。而這種思考方式正是令我可以將雙擺和太空搭載實驗比賽聯繫一起的原因。

一開始思考這個比賽的內容時候，其實我們都苦無題材，因為實驗的要求和限制都十分多，畢竟這個實驗是要上太空的，有稍微差錯和危險都可能會令到太空船發生意外。我們各人在聚會時都提出了數個想法，但這些想法都和比賽的限制有所違背，只好以放棄告終。

在休息時，我在網上看到一幅雙擺的動畫，雙擺在動畫中不規律地擺動，而且只是稍有偏差，同一個雙擺就會有很大的不同擺動方法。這樣引起了我的好奇，因為正常而言，單擺無論如何都只會左右擺動，看似平平無奇，但到底是什麼原因令單擺在接駁另一個單擺時就會出現完全沒有規律的擺動呢？

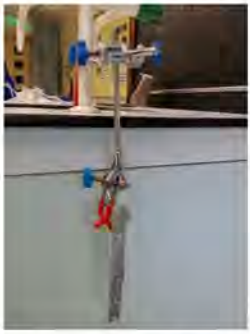
於是我就用十分方便的搜尋軟件去搜索關於雙擺的知識，得知雙擺不規律的擺動是混沌效應的體現，而就雙擺的情況而言，重力是其中一項改變他擺動方式的因素。許多人認為來到這裏就完成思考，但我就是想多了一步，太空可以提供一個微重力的環境，不知道雙擺在太空中會有什麼變化呢？於是雙擺成為我們在太空搭載實驗比賽中的題目了。

如此初步的資料當然不足夠讓我們做比賽，所以我們找了更多的資料，如李亞普諾夫指數等大專程度的研究。的確，大專程度的研究並不容易理解，但正因為對知識的熱誠，繼續成為我的推動力，令這個比賽得以完成並榮獲獎項。

雖然在文憑試中，如此的好奇可能對考試並無幫助，很多人只會死記硬背。但其實想多認識科學，好奇心是絕對不可失去的，好奇心讓我想出了這條題目並拿了這個比賽的銅獎。希望大家也可以保留自己的好奇心，並令自己學習更多、知道更多。

中國航天員中心的專家，指導同學改善實驗方案。

After students had submitted their space science project, titled, "*Chaotic or Predictable? Oscillation of a Double Pendulum Under Weightlessness Condition*" to the organizers. First-round result was announced in early of March, 2015. LFC students were fortunately to be one of the 20 shortlisted groups in the competition. Besides knowing the inspired results, another challenge has just begun waiting for them. An invaluable opportunity was given to students to meet with the Chinese space science engineering experts to provide opinions on how to modify the experiment project in order to be suitable to be carried out in a microgravity environment near the end of March, 2015. To prepare meeting with the engineering experts, the students worked hard to search for suitable materials to make the double pendulum.



The first trail model of the double pendulum.

Inquiry-based learning has a significant difference from traditional classroom teaching that even teachers cannot provide solutions for the students. Students need to find ways to solve the problems by themselves. In making the models, they were distressed on using which suitable materials to make the models. They went to many different places to try the materials they think to be suitable for making the models. After consulting opinions from the space engineering experts, students needed to modify their set-ups and put a lot of efforts to make necessary improvements. The following article was written by another participating student, *Shi Pok Lai*, sharing on the construction of the double pendulum.

Hau Pak Chuen(left), Shi Pok Lai(right)

Ma Tsz Kiu(left), Ho Long Fung Marcus(right)

After technical guidance, students were modifying the model and writing the final report for the assessment interview.

學生分享

雙擺研究的過程及意義

施博禮

(2017年畢業生，現於科大工程學系就讀)

「三、二、一、點火！」一條火柱從遠方的火箭中冒出，我們五人都興奮不已地看着徐徐升空的神舟十一號載人飛船。火箭載了我們精心設計的科學實驗模型，回想起三年來的比賽經歷，依然難以相信自己的作品能有機會在太空中進行。

我們剛得知這個比賽時，發現得獎作品有機會被帶到天宮二號實驗室進行，感到十分興奮。我和其他組員曾經在網上看過雙擺運動時隨機擺動的樣子，對它不規則的擺動感興趣，而這個比賽恰巧讓我們有機會研究雙擺運動在太空的情況，所以我們二話不說便決定進行一系列對雙擺的研究，希望能設計出一個能在太空微重力環境下進行的雙擺實驗。然而，對於四名中四學生來說，這一切研究都不容易。我們對於太空實驗室的環境不甚了解，還要閱讀一篇篇大學程度、非常深奧的科學論文，以明白雙擺的運作，看着如外星文字般的方程式，我們都一頭霧水，幸好在老師的指導下，我們慢慢開始對雙擺多了認識。

最終我們提交的設計成功進入決賽，我們開始尋找各種合適的材料製作雙擺。雙擺就是把兩支單擺連在一起，讓雙擺的上下兩部份能分別轉動，形成不規則的運動模式。最初我們以鐵和螺絲製造了一個雙擺原型，但這個設計十分笨重，外型亦不甚美觀，更重要的是單擺之間磨擦力龐大，往往在轉動不到幾秒便已經卡住。幸好決賽隊伍有機會和來自北京航天局的專家們討論實驗內容以及改良實驗的方法，我們經過一番商討之後，進一步明白到太空實驗的限制以及環境，把雙擺物料由鐵片改為鋁片，鋁片再改為膠片，令雙擺的重量減輕，亦使雙擺的動作更流暢，才成為了能夠在太空實驗室中使用的雙擺模型。

我們實驗的目的是希望得知雙擺在太空的微重力下會否如在地球上一般不規律地擺動，還是會有一個明顯、可預測的擺動方式。若雙擺在微重力下依然隨機擺動，我們便能推翻一套目前用以計算雙擺的公式，為科學帶來新的理論。而雙擺的結構其實與人的四肢相似，都有上下兩部份並由一個關節連在一起，若雙擺在太空的軌跡變得可預計，我們便能把實驗數據應用在未來的機械臂、義肢等發展中。

我們能夠在此次比賽中獲得季軍，除了高興外，亦很感謝我們的老師們一直指導我們，與我們並肩作戰。主辦單位亦給予了我們寶貴的機會，進行與太空有關的實驗，亦讓我們有幸在酒泉衛星發射中心目睹火箭發射的過程，一圓我們從小以來對太空的好奇心。經過這個比賽後，我更加明白這個世界還有很多未知的領域等待人類探索，使我決心在未來繼續努力，探索更多知識！

學生分享

獲獎的悸動

馬梓喬

（2017年畢業生，現於理大物理治療學系就讀）

「季軍，保良局羅氏基金中學。」

甚麼？我們嗎？當刻的空氣凝住了，我目瞪口呆地直視前方頒獎台上的屏幕，心裏再慢讀一次季軍的校名，是的，沒有錯，是我們，但我卻沒有跑上頒獎台的衝動，反而渴望司儀能夠再一次宣佈我們是得獎者的消息。從沒想過得獎的我們，對此又驚又喜，我和另外三個同學互相看看對方，沒有說過半點話，但是各人臉上都洋溢着喜出望外的笑容，一種難以言喻的興奮。尤記得當時黃老師雙手握起拳頭，對我們說：「Yes！Yes！我們贏了！」我們步上頒獎台，接過證書和一個火箭模型的獎座，自信地望着閃爍不停的閃光燈。這一刻，彷彿場內所有燈都熄滅，只有台上的射燈格外光猛，照耀着五個難掩興奮的勝利者。

站在我旁邊的黃老師小聲說：「我開心得胃痛了。」我忍不住笑了，但我明白，我明白這一切都是我們努力過後的成果。那一年內為這個比賽付出的種種片段在我腦內不斷重演。但是故事該從哪裏說起呢？

我想到了我們一開始接觸這個比賽時，腦袋盡是一片空白，縱使充滿着對科學的熱情，但畢竟要由零開始建構一個能夠在太空進行的實驗，對於數個高中生來說，也是頗有難度的。不過，最後我們也能成功想到，就是研究雙擺運動。為了能順利進入決賽，我們花了許多平日放學和假期的時間，埋首在實驗室打科學報告、做試驗、看大學論文等等。後來我們成功入圍，進入決賽，與北京的航天專家見了面，為實驗設計作出了多次改良，窮盡心力，一切就是為了最後決賽的匯報。

甫進入進行匯報的會議室，便看見接近二十個香港和內地航天的專家，心裡不免泛起一點恐懼，我的手開始顫抖起來，但我告訴自己：我們已經盡了所能，準備充足了。我們向專家們一一介紹我們的實驗目的和設計等等。到了問答環節，想不到專家們都搶着發問，然而那些問題都很艱深，學問不深的我們只好運用已有知識盡力回答，看着他們皺眉的樣子，我心想：或許專家們不欣賞我們的實驗。失落感湧上心頭。

正是因為那種沒法解答專家疑問的失落，令我們都覺得自己與獎無緣，所以宣佈賽果的一刻我們才那麼驚喜若狂。這個獎項無疑是一種鼓舞，站在頒獎台的我們對自己有了肯定，因為背後代表着我們殫精竭力設計出來的實驗能夠帶上天宮二號實驗室，讓太空人進行我們的實驗。興奮的心情讓我們都笑眯了眼，記者們的照相機不停咔擦咔擦，我們堅定的雙眼發出比彩虹更燦爛的動人光彩。

The Acting Chief Executive, Mrs Carrie Lam(1st left), and the Deputy Chief Designer of the China Manned Space Program, Mr Zheng Min(1st right), were presenting the award to our students.(Starting from the 2nd on the right, Ho Long Fung, Hau Pak Chuen, Ma Tsz Kiu and Shi Pok Lai.)

這次得獎為我們帶來了很多受採訪的機會，報章、電視媒體都與我們做了訪問。訪問過程中，我們都不忘分享小學和中學老師對於我們科學上的培養，才讓我們現在得以發揮創造力。記得小學時，我們便有科學堂，學一些簡單科學概念，動動小手做實驗，發掘了我們的求知慾，激發了我們發問，引發了我們思考，可是由於知識所限，很多問題也就只能留在心中而不能解答。上到中學，我們慢慢地吸收更多科學知識，小學時曾經認為是奇怪的想法和問題也就一一迎刃而解。中學有了更多機會讓我們學習科學，我們參加不同的科學學會，進行探究，對科學的興趣有增無減。恰巧，就是這個比賽，讓我們延續對科學的熱情和探究精神。

The 2nd runner-up prize of the space science competition (Model of TG-1 / SZ-10)

接二連三的採訪過後，翹首以待的日子終於到來，就是我們到酒泉衛星發射中心觀看神舟十一號發射的日子！這五天的酒泉之旅實在讓我們大開眼界。曾經的辛苦都已變得無關痛癢，唯有快樂的時光在腦內不斷重演。我們到了蘭州，行了夜市；乘搭西部高鐵到了嘉峪關，經過了大草原和雪地，看到了連綿不斷的山脈；由嘉峪關乘了七小時的車到達內蒙古的額濟納旗，途經一片沙漠，我們都站在沙漠裏，親眼看着太陽落入地平線，然後慢慢消失。最難忘的一天當然是火箭發射的一天，還記得發射的前一晚我睡不着。火焰從火箭底部噴出，火箭升空的聲音撼天動地，其後天空出現一陣白霧，火箭成功進行了第一次分離，不一會兒，火箭已經消失眼前。這時剛好是日出，彌補了火箭升空只有十多秒的遺憾，因為日出日落這兩個難得在香港一見的時刻，都讓我們目睹了。親眼看着火箭升空，與電視看到的截然不同，因為這次升空很特別，我們的實驗設計一起跟着火箭一飛衝天了！當中的滿足感難以言喻。

在餘下的兩天旅程裏，我們成了好漢，遊覽了嘉峪關長城，在城樓上看到了戈壁沙漠；在額濟納旗又一睹了大片胡楊林，金黃色的葉份外迷人。中國西北地區的景色美得如畫，一幀幀明媚風景映入眼簾，讓人目不暇給。

離別在即，纏繞着我心頭的，不單是漂亮的景色，還有這五天一生難得的經歷以及與其他得獎學校學生的點滴。這一切都讓我對這旅程依依不捨。縱使有着各種眷戀，但旅程過後，我們與他校學生也必各自星散。若時光永遠定格在那刻，凝住一切美好的事物，那該多好！然而，我相信，在不久的將來，我們會與他們再次相聚，一起回顧這短短五天卻又一生難忘的時光。

故事未有終結，我們要繼續抱着夢想，懷着對夢想的堅持和執着，繼續譜寫我們的續章。

From Shenzhou-11 to Tiangong-2

Mr. WONG Yeung, Head, Department of Physics

Within the whole academic year of 2015-2016, students kept communicating with space science engineering experts. They discussed on how to amend the experimental set-up to make it suitable for launching of Shenzhou-11 and being performed in a microgravity environment in Tiangong-2. On 24, August 2016, students were honorably invited to Shenzhen to attend a meeting with Beijing space engineering experts. During the meeting, they could see the final version of their double pendulum for Tiangong-2. Through a series of meeting with space science experts, students learnt the attitude of rigor in scientific investigation. They could also observe the creativity of those experts in doing research and wholeheartedly sharing of knowledge with students. The interaction with scientists is something students can't learn by reading textbooks alone.

Meeting with Beijing space science engineering experts in Shenzhen

The final set-up to be onboard *Tiangong-2*

Inquiry-based learning provides a lot of opportunities for students to interact with many people like students from other competing schools, scientists, astronauts, businessman reporters and even government officials. Such a wide range of people broaden the field of view for the students. Students could also learn how to explain their scientific ideas clearly and systematically to audience with no science background. In the space science project, there was a precious opportunity that students can explain their project to the former Chief Executive, Leung Chun-ying in the government house on 2nd, October, 2016. During their presentation, students interact with Chief Executive and understand the vision of Hong Kong SAR Government in developing innovation and technology in Hong Kong. Here are some photos of the event:

Students were explaining the setup the Chief Executive

Principal CHAN Wing Kwong and the LFC students in the Government House

Students may have a dream that their experiments can be brought into space. Yet, they are difficult to believe that the dream can become true one day. The moment of witnessing the launch of their own experiment to the space by students' naked eyes is an unforgettable moment for them. In 15th Oct, 2016 – 19th Oct, 2016, the Shenzhou-11 manned spacecraft was launched and carries the experiment of students to space. It is highly honorable that our students were invited to go to *Jiuquan Satellite Launch Center* (*酒泉衛星發射中心*) to witness the launching event. In the night just before launching, students who stood beside the Gobi desert, under the blanket of stars enjoy the peaceful moment which can hardly be perceived in Hong Kong, a city amidst of noises. Perhaps that night was so impressed to LFC students. One of the students, *HO Long Fung Marcus*, would like to understand more how do the stars evolve and search for the related information. The following article is his sharing on stellar evolution:

In HK airport, LFC students set out to *Jiuquan Satellite Launch Center*

The space science project provided a platform for implementing inquiry-based learning. Teachers are no longer someone who just keeps delivering knowledge inside a classroom. They provide questions for students to think of or pose a problem for students to investigate on. Students can even draft the question by themselves to investigate upon. Centre of the classroom migrate from teachers to the students. In order that students have the motivation to find out the answers by themselves. The project title should be the one in which students are interested. Teachers just need to question the validity of the processes carried out by the students. Students not only learn the content knowledge, but also understand the processes for finding out the answers. As they understand thoroughly the processes in obtaining the answers, they become more courageous to explain their ideas to other people, even to the professionals. To achieve the space science project, students solve the problems one by one. Finally, they present their ideas in front of other schools' students, scientists, space engineering experts, and even the chief executive. These moments are unforgettable and unexpected to them. In the past, they were so dependent on teachers for giving them the answers. Now, they have grown up and are capable of finding the answers by themselves. Relying on the through-train LHT-LFC education, students can be equipped with inquiry-based learning since they are in primary schools. They can have plenty of practices to change from a passive learner to an active one. The future world waiting for the students is complex and needs the new generation to be innovative, creative, think-critically, cooperative and technologically well-sensed to solve the problems. Inquiry-based learning enables students to have a glimpse of the complexity of real life problems. In the space science project, it is hoped that students not only remember those magnificent sights, but also the rigorous, serious attitudes in doing scientific research, as well as the perseverance in finding out the truth. Hong Kong students are usually regarded as vulnerable, especially in front of challenges. It is hoped that inquiry-based learning can make them optimistic and courageous to solve the problems.

Student's sharing

Stellar Evolution

HO Long Fung Marcus

(S.6 Graduate in 2017; Student of Bachelor of Architectural Studies in The Chinese University of Hong Kong)

Every night, billions and trillions of stars are shining in the sky above the city we are living in. Some of you may simply ignore them and focus on you own business, while some of you may look up and enjoy such a wonderful view. Living in the 21st century, you should have heard some terms about astronomy (e.g. black holes（黑洞） and gravitational collapse（引力崩潰）) somehow through news or other shows, but I belief that most of you should not know what's going on in the universe, right? Therefore, I am going to tell you the whole stellar (adj. of 'star') evolution.

The first step is a protostar. Protostar is actually a cloud of inter-stellar gas and dust in space; they are brought together by each other due to gravitational force. This process is called 'gravitational collapse', during so the gravitational potential energy(重力勢能) is converted into kinetic energy(動能), thus temperature increase. If the mass is below 0.08M⊙(M⊙=Mass of Sun, 1.99×10^{30}kg[1]), the sphere will simply cool down afterwards. This kind of star is called 'brown dwarf', and if it orbits around a star, it can be called a 'planet' (the one we are standing on!).

If the mass is above 0.08M⊙, the temperature will be able to exceed 10 million degrees[2], starting the nuclear fusion of hydrogen (Fusion is a reaction combining lighter nuclei into a heavier nucleus, light and heat are produced during fusion, the corresponding equation is $E = mc^2$). Once fusion of hydrogen is initiated, it passes from protostar to main sequence.

In main sequence (the process when the core of star is fusing hydrogen), the outward thermal pressure generated by fusion balance the inward gravitational force, and so a dynamic equilibrium is reached. Therefore, the star stops collapsing and remains stable. Stars with mass 0.08-0.5 M⊙ are called 'red dwarf'[3], and they make up 3/4 of the stars in the Milky Way galaxy[3]. Finally, when all hydrogen is used up, main sequence ends and the further fate of the star depends on its mass:

Low-mass stars (0.08-0.5M)[3]

As the fusion of hydrogen stops, the thermal pressure decrease, so the equilibrium is

[1] https://en.wikipedia.org/wiki/Solar_mass
[2] https://en.wikipedia.org/wiki/Stellar_evolution
[3] https://en.wikipedia.org/wiki/Red_dwarf

broken and the star collapses again and temperature rises again. As the mass is too small, the temperature is too low to fuse helium, so nuclear fusion ends. The red dwarf collapses into a white dwarf (much smaller in size), which is now supported by the electron degeneracy pressure against further gravitational collapse instead of thermal pressure. The remaining energy contributes to the temperature and luminosities of the white dwarf. This kind of white dwarf is made of helium only.

When the remaining energy in a white dwarf finally dies out, it becomes a black dwarf, which is cold and dark. However, as the universe is still too young for the appearance of black dwarf, existence of it is still in theoretical level. If a white dwarf can accumulate materials from a binary companion, its core temperature can increase and may trigger nuclear fusion and cause supernova.

Mid-sized stars (AGB stars) (0.6-10 M⊙)[4]

The mass of AGB stars are large enough so that the temperature can exceed the minimum temperature to start fusion of helium (300million degrees)[4] when their cores collapse again. The fusion of helium is called 'triple-alpha process', its main products are carbon and oxygen, minor products include neon, magnesium and even heavier elements. Therefore, there will be an outermost layer of burning hydrogen on top of a layer of burning helium, and which is on top of a core made of carbon and oxygen.

Mid-sized stars with mass above 7 M⊙ are called super AGB[4], their carbon-oxygen cores are big enough to ignite carbon fusion in a mechanism similar to the helium ignition. The thermal pulse may cause the super AGB to explode as a supernova (molecular cloud), but most of the super AGB will not.

No matter it is 'super' or not, when the fuel in the shell and core all used up, pressure of core decreases, the core collapses and becomes a hot central star. The radiation from core exerts radiation pressure on the outer layer, so stellar wind is formed due to such pressure and it blows the outer layer away from the hot central star as 'planetary nebula' (molecular cloud). The hot central star will finally convert into a white dwarf made of carbon and oxygen or oxygen and neon (super AGB), and the fate of white dwarf is same as the helium white dwarf mentioned above.

Massive Stars (above 10 M⊙)[5]

It is similar as mid-sized stars, massive stars ignite helium and carbon in the core, but massive stars are capable to further ignite neon and other heavier elements, forming several layers. Meanwhile, as the radiation pressure is very high, the strong stellar wind

[4] https://en.wikipedia.org/wiki/Asymptotic_giant_branch
[5] https://en.wikipedia.org/wiki/Supergiant_star

will blow a lot of matters away from the star, stars above 40 M⊙ may even have their outer layer stripped off[2]. Therefore, the maximum mass of stars cannot exceed 150 M⊙.[2] Eventually, cores of iron and nickel are formed. As further fusion of iron do not have net energy release, fusion stops and the core collapse rapidly. As their mass are too heavy, electron degeneracy pressure is not enough to oppose the gravitational collapse. White dwarf cannot be formed, and the cores further collapse.

If the mass of core is below 3 M⊙ (which means the mass of the star is 10-29 M⊙ at main sequence) , the neutron degeneracy pressure would be enough to withstand the gravitational force. Meanwhile, the great amount of heat released in the collapse before allows reversed beta decay to occur, which further release more energy and thus cause a supernova explosion. Reversed beta decay also converts protons and electrons into neutrons, so the core becomes a neutron star afterwards.

Neutron star is a giant (radius of around 10km)[6] atomic nucleus made of almost 100% neutron. It is the smallest and densest star; a normal-sized matchbox with neutron-star material inside would have a mass of approximately 3 billion tonnes, or a 0.5 cubic kilometre chunk of the Earth!

If the mass of the core is above 3 M⊙ [7](which means the mass of the star is above 29 M⊙at main sequence), even neutron degeneracy pressure is not enough to withstand the gravitational collapse, and so it finally collapse into a black hole.

Finally, the molecular cloud from supernova and planetary nebula may collapse and form some new protostars.

This is the brief summary of the stellar evolution. Hope that it can give you a basic concept of what's going on in the sky when you look up at night the next time.

[6] https://en.wikipedia.org/wiki/Neutron_star
[7] https://www.nasa.gov/audience/forstudents/9-12/features/stellar_evol_feat_912.html

學生分享

酒泉神州十一升空之旅

何朗峯

(S.6 Graduate in 2017; Student of Bachelor of Architectural Studies in The Chinese University of Hong Kong)

10月15日(星期六)　千里之行始於足下

星期六的大清早，一覺醒來的我不再埋首於功課、書本堆中溫習，而是踏上前往酒泉之旅。第一次與同學離港旅行，倍感興奮；第一次在非假期時段旅行，倍感新鮮；第一次在現場觀看火箭升空，倍感期待。前往機場的路上難免有些不真實的感覺。

在機場內，我們一團人整裝待發，穿上「神州十一號升空考察團」制服，浩浩蕩蕩地上機。第一天的旅程，我們主要在機場、機艙和旅遊巴士中渡過，單單在飛機上，我們已用了6小時。雖然沒有甚麼精彩的事件發生，但正由於有極多的空餘時間，我善用了每分每秒完成大部分的功課，總算沒虛度光陰！若要分享一件較為深刻的事，那一定是我們的晚餐。雖然大部分都是名貴的高級食材，但是當地人偏愛麻辣的菜式，令我們有點吃不消。然而，我們沒有因此而顯得尷尬，反而借題發揮、有說有笑、互相交流。

總結第一天的旅程，我們的待遇比預期中好，令我們頗為意外。在香港機場時，領隊給我們一大袋乾糧；在上海機場，大會請我們到一家酒樓吃價錢不菲的午餐；在蘭州安頓後，大會更請我們到高級酒店晚餐。我相信自己一定能好好享受這次旅行。

10月16日(星期日)　攀山涉水長途跋涉

早上大約7時，我們趕到車站踏上4小時高鐵之旅。途中經過一大片平原，令我不禁讚嘆着大自然的壯觀和美麗。當我們途經超過海拔三千米高的高山，高山症使我腦袋出現一陣劇痛，幸好最後還是能夠硬撐過去。

我們於十二時到達嘉裕關後，便乘坐七小時的旅遊巴士到達酒店。由於公路並不平坦，所以在這七小時中，連看看書也做不到，更不用說做功課。於是，我決定放棄工作，抱頭大睡。然而，由於巴士的振動太大，椅背每秒都在拍打著我的頭，所以不易入睡，亦令我一直頭痛胃漲。這顛簸路程令我十分懷念在香港乘車、乘地鐵時的平穩暢順感。幸好，領隊每二小時便會到休息站停一停，讓我們能竭一竭。我終於切身體會到「休息是為了走更遠的路」的意思了。

我們在酒店吃過晚餐後，休息了大約二小時。然後於晚上十一時再

度乘坐巴士，並於零晨二時到達火箭發射場外五公里的觀看區。由於二時起所有車輛都要停駛，我們下車逛了一圈後，便立即回到車上睡覺。雖然連日的趕路令我身心俱疲，但我明白凡事要付出才會有成果，想要親身目睹火箭升空這寶貴的時刻，就必需忍耐路途上的艱辛。

10月17日(星期一)　一分耕耘一分收獲

清晨六時多，我們走出車外，為此行重頭戲一觀看火箭升空，作好準備，然後於七時三十分靜待一切來臨。在寒風刺骨、一望無際的大平原上，喇叭中一把洪亮的聲線倒數着：「十、九、八……」。數完「一」之後，我們都屏息靜氣，立時全場鴉雀無聲，然後發射台突然被大片濃煙灰塵籠罩着，十多秒後，一陣頻密而震耳欲聾的爆炸聲趕來，大地亦因此微微震動。此時，火箭的輪廓已突破濃煙灰塵，開始往萬里無雲的天際筆直衝去，幾十米高的火焰自火箭底部噴射出來。片刻之後，火箭已升上幾公里高，一陣白霧突然從火箭噴出，第一階段分離成功。再過一會兒，火箭變得像天上的星星一樣細小，最後消失在我們的視野中。

雖然火箭發射的片段在新聞報導中也屢見不少，但在家中觀看重播遠遠比不上在現場觀看震撼，就像在看台上觀看一場比賽和在新聞中看精華片段一樣。新聞中只有一幕幕的片段重温，但在現場卻是親歷其景。新聞充其量只能提供火箭升空的視聽效果給觀眾，但身處現場的我，有著不再限於電視屏幕的視野和截然不同的氣氛。凜烈的強風吹送著陣陣的火藥味，在升空的那一刻，誰也無法預測火箭是否真能順利升空，直到火箭從我們的視線中遠去，緊張的氣氛令人有窒息的感覺。能夠在現場親身目睹火箭發射的情景，實在難能可貴。回想起這兩天長途拔涉的旅程，一切都是值得的。因此，我十分珍惜是次的經驗，把這重要的時刻用紙筆、用相機、用心，一一記錄下來。

Shenzhou-11 leaves a lot of hot gases when heading towards the space

Just after the launch of the spacecraft

10月18日(星期二)　行萬里路見多識廣

休息了十多個小時之後，我們在早上八時繼續行程，到達嘉峪關的一大景點—嘉峪關關城，這是長城西端的終點。古城坐落在一片黃綠色的樹林中，加上陽光的襯托，十分優美。讓我意識到中國雖然一直被人批評環境污染嚴重，但其實在其西北部仍然有一片美麗的自然景觀。

遊覽了短短一個多小時之後，我們便立即趕到嘉峪關市酒鋼三中進行交流。雖然酒鋼三中只是一所高校，但卻令我們大開眼界。酒鋼三中給我的第一印象就是「大」。酒鋼三中就像香港科技大學那麼大，正門後方有幾幢羅氏基金中學那麼大的建築，又有自己的運動場，四個大飯堂，光是籃球場就有八個。另外，可能是由於北方人的血統的關係，迎接我們的學生雖然只是高二級，但男生大部分都約一米八，女生也有一米七。相比之下，我們的團友很多人都顯得像小學生一樣。

晚上，我們三間學校的師生一起到夜市閒逛，那裏有很多街邊小檔。我們買了些食物到路旁的座位品嚐，談天說地。雖然時間並不算長，但我們之間的友誼仍然有很大的增長，盡興而歸。

Visiting Jiayuguan(嘉裕關)

Sharing in酒鋼三中

10月19日(星期三)　有驚無險迎來終結

這天，我們踏上了歸途，乘坐飛機由蘭州到西安轉機，再回到香港。由於我們在登記處排隊排了很久，比預期中消耗了更多時間，所以我們登機前十五分鐘還在登記，開始登機時才完成安檢。眼見上機的時間越來越緊迫，通過安檢後，我們便立即全力跑到登機坪，幸好趕上了尾班載人到飛機的巴士，我們差點不能上機。然而，為了通過安檢，我喝光了水壺中的水，所以趕上巴士後差點便嘔吐了。這件事令我明白到，凡事都未必能盡如人意，在重要的時刻，我們應該要做好最壞的打算，不能過度理想化。若果預留了多一點時間準備，我們便不必如此趕急和難受了。

我們在下午八時抵港，一起相處了五天之後，終於要分道揚鑣了。雖然天下無不散之筵席，但我們也有把握最後機會一起在機場拍照留念，互相交換聯絡資料。然而，我們一定還會再見的，因為主辦單位已計劃等到實驗出結果後，會再次相約我們一同吃飯。

Inquiry-based Learning in Social Science Education

Mr. LEUNG Wing Kin, Head, Department of Geography

One of the objectives of the establishment of Ecology Laboratory is to strengthen the support in Advanced-level Research-based Learning. This mode of learning is often correlated to international youth conferences. Through these conferences, students exchange their ideas and vision with scholars and youth across the globe culturally and academically.

As at September 2017, over 110 students in Social Science have taken part in 16 international youth conferences and competitions held in 15 regions/ countries in Asia, Europe and America.

Advanced-level Research-based Learning was firstly introduced in 2006 in Social Science. In July 2007, five students took part in the 21st Youth Conference of Caretakers of the Environment International held in Hong Kong. Since then, the participation in international youth conferences have become a regular annual event. Commonly, activities in these conferences include (1) Research presentations; (2) Workshops; (3) Fieldtrips and (4) Cultural exchange.




In these conferences, under the guidance of teachers, students in teams carry out researches on certain environmental issues under the conference theme. During these seven-day conferences, students present their findings overseas to youth from many countries. It also aims to create backwash effects on the ordinary learning in classrooms. For examples, students are expected to demonstrate better presentation skills; they are also equipped with high order skills in environment which are beneficial to their school-based assessments.

Conference / Competition	Date	Location	No. of students
21st Youth Conference of Caretakers of the Environment International	7-14 Jul 2007	Hong Kong	5
24th Youth Conference of Caretakers of the Environment International	4-10 Jul 2010	Lawang, Indonesia	9
2nd International Workshop on the Science and Conservation of Asian Horseshoe	13-16 Jun 2011	Hong Kong	3
25th Youth Conference of Caretakers of the Environment International	1-10 Jul 2011	Debrecen, Hungary	13
UNESCO Jilin Green Forum	25-30 Jul 2011	Jilin Province, NE China	7
3rd Assembly of Youth for Environment	15 Nov 2011	Singapore	7
26th Youth Conference of Caretakers of the Environment International	1-7 Jul 2012	Maastricht, The Netherlands	8
27th Youth Conference of Caretakers of the Environment International	4-14 Jul 2013	Ardlui, Scotland	4
28th Youth Conference of Caretakers of the Environment International	4-12 Jul 2014	Yilan, Taipei	8
3rd International Workshop on the Science and Conservation of Horseshoe Crabs	15-19 Jun 2015	Sasebo City, Nagasaki	7
29th Youth Conference of Caretakers of the Environment International	28 Jun - 4 Jul 2015	Lisbon, Portugal	8 LFC 4 LHT
30th Youth Conference of Caretakers of the Environment International	28 Jun - 4 Jul 2015	Aalborg, Denmark	9 LFC 4 LHT
31st Youth Conference of Caretakers of the Environment International	29 Jun- 9 Jul 2017	Salem, USA	3 LFC 4 LHT
4th International Workshop on the Science and Conservation of Horseshoe Crabs	25 -28 Aug 2017	Bangkok, Thailand	5

LFC: Po Leung Kuk Laws Foundation College
LHT: Po Leung Kuk Luk Hing Too Primary School

Advanced Facilities in Law Cheuk Ecology Laboratory

Hydrological science: Spectrophotometer (Lovibond SpectroDirect)

There are more than 200 rivers in Hong Kong, with a total length of over 2,500 km. These rivers are both crucial source of fresh water and habitats of many flora and fauna. Unfortunately, rapid urban development and human activities do not only modify the physical environment of the river channels, but also upset the quality of the river water.

With many reagents, the spectrophotometer can measure various chemical pollutants and heavy metals in water samples, for example, turbidity, ammonia, nitrite, nitrate, nickel.

From November 2013 to May 2014, a study on river quality was carried out by a team of students. Lam Tsuen River, sourced from Tai Mo Shan and flowing through Tai Po New Town, was selected. Throughout their study, a total of 33 water samples were taken at the middle course (Ma Po Mei) and lower course (Mui Shue Hang and Kwong Fuk Bridge).

To make students more efficient in analysis, a Water Quality Record and Comparison Form has been developed. This form allows students to compare the water quality quickly with tap water, distilled water and the recommendations from World Health Organization (2011). Thus, students are able to determine the quality and drinkability of the water samples under tests easily.

Advanced Facilities in Law Cheuk Ecology Laboratory

Atmospheric science: Monitors for aerosol (TSI Dust-trak II 8532), nitrogen dioxide and sulphur dioxide (Aeroqual Series 500 Portable Air Quality Monitor))

Respirable suspended particulates (RSP, PM_{10}) and fine suspended particulates (FSP, $PM_{2.5}$) are two common air pollutants found in Hong Kong. Together with sulphur dioxide, ozone and nitrogen dioxide, they construct the Air Quality Health Index (AQHI), which has come into operation since December 2013.

The aerosol monitor is a light-scattering laser photometer that provides real-time aerosol mass readings. It is used to quantify the density of suspended particulates of various sizes, for example, respirable suspended particulates and fine suspended particulates. This device can measure suspended particles as tiny as 0.1 μm (0.0001 mm) in diameter.

Nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) are two other major air pollutants in Hong Kong. They are produced in combustion processes. Power plants and vehicles are their major sources.

The handheld monitors allow real-time surveying of nitrogen dioxide and sulphur dioxide. Ranges of detection are 0 - 1 parts per million (ppm) for NO_2 and 0 - 10 ppm for SO_2 respectively. Data stored in the monitor can be uploaded to personal computers for further analysis.

Under the support of Prof. Authur P.S. Lau, Division of Environment, The Hong Kong University of Science and Technology, three teams of students carried out their researches on the air quality of the campus. In their researches, the levels of five air pollutants, namely RSP, FSP, nitrogen dioxide and ozone, are measured from November 2015 to May 2016.

Further, to locate the possible sources of these pollutants, the levels of pollutants are compared with various meteorological parameters, for instance, temperature, wind speed and direction, relative humidity etc.. Students presented their findings in the 30th Youth Conference of Caretakers of the Environment International, which was held in Aalborg, Denmark in July 2016.

Student's Research Project in the 28th Youth Conference of Caretakers of the Environment International 2014

Interaction among men and nature:

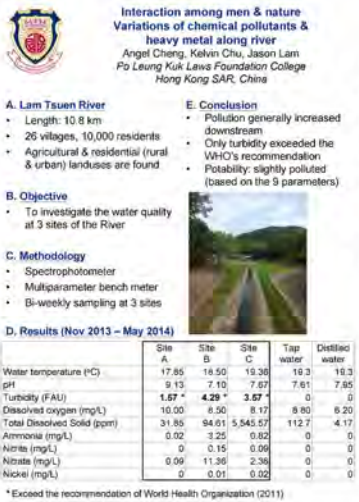
Variations of chemical pollutants and heavy metal along river

CHENG Wing Yan (S3), CHU Sing Ip (S3), LAM Yik Hang (S5)

Striking a balance between conservation and development has long been a controversial issue raising the awareness of people from all walks of life. It is essential for Hong Kong as a metropolis which lacks nature conservation, to promote sustainable development.

Lam Tsuen River is one of the few remaining undistributed rivers in Hong Kong. It is a 10.8 km long river located in the northern part of the city. There are 26 villages with more than 10,000 people living along. The River is also an important site for the commercial farming of flowers and vegetables. The River also carries cultural significance: The "Wish-making Tree" in the middle course attracts thousands of local and overseas tourists. Tourists throw offerings tied with oranges onto the tree branches, making their wishes and hope to have good luck in every New Year of Chinese.

In the present study, the river water is sampled bi-weekly at three checkpoints from November 2013 to May 2014. Nine water quality parameters, namely temperature, acidity, turbidity, dissolved oxygen, total dissolved solid, ammonia, nitrate, nitrite and nickel, are examined in the school laboratory through various apparatus, chemical reagents and spectrophotometer.



Interaction among men & nature
Variations of chemical pollutants & heavy metal along river

Angel Cheng, Kelvin Chu, Jason Lam
Po Leung Kuk Laws Foundation College
Hong Kong SAR, China

A. Lam Tsuen River
- Length: 10.8 km
- 26 villages, 10,000 residents
- Agricultural & residential (rural & urban) landuses are found

B. Objective
- To investigate the water quality at 3 sites of the River

C. Methodology
- Spectrophotometer
- Multiparameter bench meter
- Bi-weekly sampling at 3 sites

D. Results (Nov 2013 – May 2014)

	Site A	Site B	Site C	Tap water	Distilled water
Water temperature (°C)	17.85	16.50	19.36	19.3	19.3
pH	9.13	7.10	7.67	7.61	7.95
Turbidity (FAU)	**1.57** *	**4.29** *	**3.57** *	0	0
Dissolved oxygen (mg/L)	10.00	8.50	8.17	8.80	8.20
Total Dissolved Solid (ppm)	31.85	94.61	5,545.57	112.7	4.17
Ammonia (mg/L)	0.02	3.25	0.82	0	0
Nitrite (mg/L)	0	0.15	0.09	0	0
Nitrate (mg/L)	0.09	11.36	2.36	0	0
Nickel (mg/L)	0	0.01	0.02	0	0

* Exceed the recommendation of World Health Organization (2011)

E. Conclusion
- Pollution generally increased downstream
- Only turbidity exceeded the WHO's recommendation
- Potability: slightly polluted (based on the 9 parameters)

Through analyzing these water samples, the impact of human activities along the River have been shown. Some pollutants that are hazardous to the ecosystem like ammonia, nitrate, nitrite and nickel are found in the River. It is shown that, among the nine parameters examined, three have exceeded the standard of drinking water advised by the World Health Organization.

Lam Tsuen River is a river with significant agricultural, cultural and ecological importance. To alleviate the problem of water pollution, timely actions should be taken by the government and residents along the River, for a sustainable development of the River and the basin.

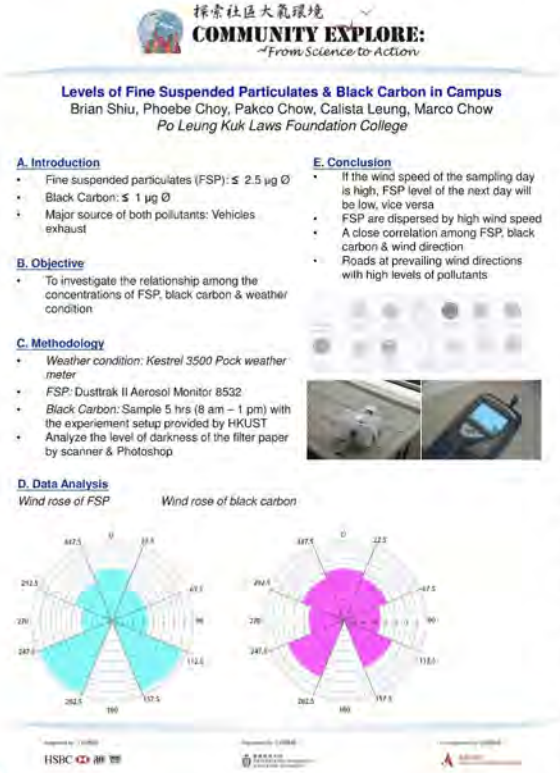
Student's Research Project in the 30th Youth Conference of Caretakers of the Environment International 2016

Levels of Fine Suspended Particulates and Black Carbon in Campus

CHOW Pak Ho (S4), CHOW Hui Yau (S4), LEUNG Hok Yiu (S2), CHOY Yi Ting (S4), SHIU Hin Yeung (S4)

Suspended particulates refer to particles in the air with a diameter of 100 micrometers (0.1 mm) or less. It can be further classified according to their size, for example, respirable suspended particulates (RSP) are those particulates smaller than 10 μm in diameter; fine suspended particulates (FSP) are those less than 2.5 μm.

In Hong Kong, suspended particulates is one of the major air pollutants. The annual mean RSP concentration at business center reaches 46 μm/m3, with a maximum of 201 μm/m3 (2014). During winter time when wind prevails, northerlies bring particulates from the highly industrialized Pearl River Delta to Hong Kong, worsening the problem. Studies have proved that RSP can damage breathing and circulatory systems. At worst, it may cause lung cancer.



In the present study, the relationship among various weather elements (temperature, relative humidity, wind speed and direction) and RSP/ FSP is investigated. Through this investigation, the prime source of RSP/ FSP can be identified, assisting further planning of remedial measures in alleviating the problem.

Student's Research Project in the 30th Youth Conference of Caretakers of the Environment International 2016

Levels of Nitrogen Dioxide and Ozone in Campus

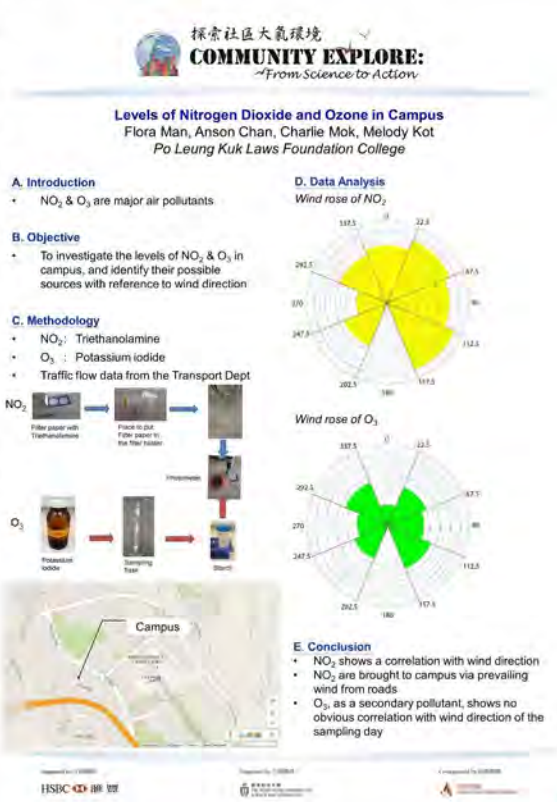
MAN Hiu Ching (S4), CHAN Shu Ham (S2), MOK Ching Yin (P6), KOT Yin Laam (P6)

Nitrogen dioxide is one of the major air pollutants in Hong Kong. Its main sources include combustion engines in vehicles and thermal power plants. During combustion, NO2 is released into the atmosphere.

Ozone is a pale blue gas with a very pungent smell. Naturally, it is found in the lower part of the stratosphere. It is responsible for breaking down ultraviolet light, which is harmful to lifeforms. However, chemical reactions with other air pollutants in the atmosphere create ozone in the air near the ground. Ozone has a strong irritant and harmful to health.

The trend of O3 in Hong Kong is increasing. From 1996 to 2014, the annual average of the concentration of O3 has increased 47%, from 28 μg/m3 to 41 μg/m3; the concentration of NO2 in Hong Kong has also increased 9%, from 55 μg/m3 to 60 μg/m3.

In the present study, the relationship among various weather elements (temperature, relative humidity, wind speed and direction), NO2 and ozone are investigated. The trends of these two pollutants will help raise the awareness of our classmates, and turn their concerns into actions.



Student's Sharing

How do international conferences equip me the skills for the society?

CHU Sing Yung

(S.6 Graduate in 2013; Student of Bachelor of Pharmacy in The University of Hong Kong)

Leader-in-Chief in the conferences of Hungary (2011), Singapore (2011), The Netherlands (2012)

International conferences joined: 4

Attending international conferences, without a doubt, was the most enjoyable and rewarding part of my secondary school life. Not only was I able to exchange knowledge and make friends with teenagers from different parts of the world, but I was also given the opportunities to reflect upon local environmental issues and think about how I can contribute to the society. Speaking as a fresh graduate who will be soon engaging in the labour force of the society, I have come to realise the conferences I attended have subconsciously equipped me with characters and skills to face challenges in the real society.

In this technological era, with routine jobs gradually replaced by artificial intelligence, the society needs people more than simply following the norms and instructions. On the contrary, people are wanted to spot out the inadequacies, make changes and better the world. Yet, making changes often results in opposition, due to a fear of the unknown. Thus, immense bravery is required to take the first step.

In 2012, few groupmates and I observed our schoolmates were consuming a significant number of bottled water every day but recycling facilities were

insufficient. Thus, we initiated a recycling campaign by setting up recycling facilities in the campus and organising visits to recycling facilities. Eventually, students were seen to possess a higher awareness towards environmental protection.

Personally, my confidence has been built over the years of attending conferences. Not only am I now more confident to share ideas in front of crowds in a second language, but more importantly, I am more assured of my ability to make changes to both the environment and society. Before the commencement of this project, I would have never imagined being able to change schoolmates' habit. Yet, as long as we took the first step and made our voice of good intention heard, the project went smoothly and positive outcomes were received.

Despite a good intention, a good leader is crucial in project implementation by coordinating resources and exploring room for improvement. Throughout the years of attending conferences, my role gradually changed from a member, a group leader to the Leader-in-Chief, overlooking all groups. This allowed me to understand that leadership isn't necessarily equivalent to a hierarchy. Treating teammates with a peer-to-peer level can in turn facilitate more fruitful discussions, benefiting the whole project.

Last but not least, I believe developing global vision is one of the essential skills required nowadays since the rapid growth of globalisation has masked borders between countries and facilitated information exchange. Meanwhile, attending international conferences has broadened my horizons and help me think from a global perspective. Through discussing environment issues with teenagers from different parts of the world, I have realised culture has played an important role in determining the solutions and outcomes. Thus, when it comes to making a change, instead of thinking the local need, I started to appreciate how my initiatives can be modified and incorporated into other cultures to produce a great impact.

Student's Sharing

How do environmental researches enhance my research skills?

CHOW Hui Yau (6J)
Leader-in-Chief in the conference of Denmark (2016)
International conferences joined: 2

Environmental researches equip me research skills. This is particularly beneficial to the presentations in ordinary lessons like Liberal Studies, English Language and Chinese Language. When I was small, most projects were completed by second-hand data from the internet. Through the intensive researches for international conferences, I realize the importance of acquiring first-hand data and filtering information from the internet.

Reading is an essential part in environmental researches. I learnt to pick up the useful information from long passages. As a team leader, my role is to centralize and assess the information collected by team members. Not only picking up the best information, but also to present them in a concise way. It is definitely a challenge for us to deliver a research of eight months verbally within 15 minutes in the conference.

During the course of researches, with abundant opportunities in literature review, data collection, data analysis, compiling report etc., I now have the ability in carrying out a research efficiently and effectively. I am also more ready to face the uncertainty and challenges the Q&A sessions at the end of each and every presentation.

Student's Sharing

How do environmental researches raise my awareness towards the environment?

SHIU Hin Yeung (6M)
Team leader in the conference of Denmark (2016)
International conferences joined: 2

International conferences have provided me opportunities not only in research skills but also developed my awareness towards our environment. By carrying out environmental researches, I understand more about the recent environmental problems. For instance, we collaborated with the Division of Environment, The Hong Kong University of Science and Technology in 2016 to investigate the air quality of our community. From the processes of data collection and analysis, I understand that there is indeed a close relationship between the concentration of air pollutant and wind speed.

Environmental researches involve me deeply into a particular environmental issue. I discover the beauty of the environment, strengthening my determination in environmental protection. In 2012, our group did a research on mangroves. During the investigation, Jason and I conducted fieldworks in many swampy areas. We discovered that there are many unique animals and plant species, for example, mudskipper, fiddler crabs etc.. Both Jason and I think that mangrove is really a fabulous place with high ecological value. Through this first-hand experience, we devoted ourselves to the environment and eventually think of many new means in conserving the mangrove areas.

In addition to the environmental researches completed by us, international conferences also offer me opportunities to understand the environmental issues in other parts of the world. In international conferences, participants from many countries exchange their opportunities and difficulties in environmental conservation.

Our environment is actually a miracle and it is full of vitality. I am really proud to be a member of the international conference team. After engaging in environmental researches of different areas, I am getting closer with the environment, and it also helps build myself to be a true caretaker of the environment.

Student's Sharing

How do international conferences enhance my social skills?

CHOW Pak Ho (6M)
Team member in the conference of Denmark (2016)
International conferences joined: 1

Before the participation in my first youth conference, when making new friends, I was often not the first one to speak. This was because I had no idea on the subjects of conversation I should start with.

In the conference held in Denmark, teenagers from different parts of the world gathered. Making new friends was actually not as difficult as I thought. Soon after arrival, through a few words of introduction to myself, I made my first buddy in this youth conference.

Throughout this seven-day conference, I realized that the first step to make new friends is to show mutual respect, simply by asking their names and greet politely. Don't be shy to ask for their names because it is natural that people wish to meet new people.

As a rule in this conference, we shared tables with other participants in canteen. I firstly found it quite hard to join a table full of strangers. However, foreigners were often welcoming. We sat together, enjoying the meals, and most importantly, talked about our hobbies and interest such as sports, instruments and cuisine. Sometimes, we also talked culture, festivals and weekend activities. Once the conservation starts, subjects of conservation pop naturally.

I used to be nervous and shy when talking to newly-met people. Yet I find myself changed after the conference. I am more able to start a conversation quickly with new friends. When meeting new people, there is actually nothing to worry to be the first one to talk.

學生分享

國際馬蹄蟹保育會議・曼谷・2017

林安瑜(5V)、胡健為(6M)、倫淑枝(6S)、張潤禧(6M)、彭焌琋 (5M)

是次到曼谷出席國際馬蹄蟹保育會議，由思考研究題目、進行研究，至出發前往匯報，長達半年時間。最初的時候，我對馬蹄蟹的認知就只有西貢海鮮酒家用來吸引顧客的擺飾，我們都不知道香港的馬蹄蟹是一種瀕臨絕種的海洋生物。但經過數月的資料搜集、實驗和出席科研會議後，我們對馬蹄蟹有更多的了解。

我們的研究主要是嘗試推動海鮮酒家參與馬蹄蟹保育工作，希望海鮮酒家可以借出成年馬蹄蟹到學校的生態實驗室，以電流刺激馬蹄蟹以提取卵子和精子，並在生態實驗室中進行人工繁殖，孵化幼年馬蹄蟹。在香港附近水域，有不少成年馬蹄蟹被漁民意外捕捉，伴隨其他海鮮售予西貢等地的海鮮酒家。因此海鮮酒家是成年馬蹄蟹的一個重要來源。加上要在香港野外找到成年馬蹄蟹十分困難，這更凸顯了海鮮酒家在提供成年馬蹄蟹作為繁殖源的關鍵角色。

在研究過程中，我們常常要在假期或放學後的時間到西貢海鮮酒家借馬蹄蟹和做實驗。實驗時，有些馬蹄蟹一直沒有什麼明顯反應，所以我們也有沮喪的時候。做實驗並不輕鬆，但一日未有結果也不能放棄。我們一共嘗試了十六次的電流刺激實驗，雖然並不是全部成功，最終亦未能成功人工繁殖，但我認為這個計畫對我們來說不僅是一個科學研究，更令我們體會到保育的重要性。馬蹄蟹自身對現代科研有莫大貢獻；而我們得以借助是次機會為保育出一分力，向整個馬蹄蟹研究界別提供一丁點數據，儘管效果或許不甚顯著，但亦令我們明瞭自己的責任，以及保育之於我們的意義。

回看這些參與科學會議的經驗，我們學到怎樣與陌生人進行合作，商借馬蹄蟹；經常與海鮮酒家來往，我們對海鮮酒家的運作有更多了解，在未來或有機會可以發展出一個針對海鮮酒家中的馬蹄蟹保育方案。正如是次研究，便是看到成年馬蹄蟹被囚禁在海鮮酒家，我們便針對這一點想到合作方案，在各種限制中找到保育方法。

到曼谷參與會議時，我們觀察到科學家在匯報他們研究成果時，都會著眼於推廣新科學概念，並與科學家一同討論。我們在會議中亦了解

到馬蹄蟹在世界多地所面臨的威脅，例如新加坡有一片馬蹄蟹棲息地正受到外來青口入侵，大量青口覆蓋泥灘，令馬蹄蟹未能在該地繁殖。原本這些侵佔只是季節性，但近年漸趨嚴重，幾乎從不散退。來自新加坡的學者帶出一項信息——保育的同時，也要留意棲息地的改變，這才能有效地進行保育。我們發現所謂的保育，並不只是針對物種，更是牠們的生境——泥灘和紅樹林。

欣賞過不同科學家的報告後，我們更清楚知道一份完整報告該如何去建立。令我們感到驚訝的是，科學家們的演講方式和我們想像中非常不同：他們的匯報和簡報都比較注重數據，相片比較少，對一般人而言比較沈悶，但參考價值和可信度卻是很高。

到我們匯報的時候，幸好我們有足夠的準備，匯報非常順利，並得到來自各國教授和學生的讚賞。要在這個如此盛大的科研會議，向科學家和教授匯報這六個月來成果，確實不容易。面對各種提問，我們也學到經過深思熟慮後才回答。

時光荏苒，四天的旅程很快就結束了。我們所收穫的，豈止是馬蹄蟹的資訊。我們獲得的是和科學家進行高水平的學術討論的經驗。這絕對是一個無可被取代的一個旅程。透過這會議我們深切體會到那怕是區區一人，只要大家願意培養保育意識，皆足以作出一點點改變。以我們一行五位中學生為例，雖然這次是首次嘗試電流刺激馬蹄蟹，當中的數據也許對將來的研究有一定幫助。相信只要每個人都為保育貢獻心力，可能只是少吃一頓海鮮，積少成多，累積下來的成果，終究也是真正做到保育物種這個目標。

Chief Executive Award for Teaching Excellence in Science Education

Dr. SUEN Ka Chun, Ms. LIN Mei Yu and Mr. LI Man Ho
Board of Science

In the academic year of 2016/2017, we were pleased to receive Chief Executive's Award for Teaching Excellence (CEATE) in Science Education. This award indicates that our school has demonstrated teaching excellence in the following 4 domains in Science Education: Professional Competence, Student Development, Professionalism and Commitment to the Community (Reference: Excellence Indicators in CEATE). Moreover, our science curriculum is appreciated to show strengths on (i) development of primary to secondary science programmes to promote students' interest, curiosity and creativity in science, (ii) application of teaching strategies in science lessons to help students actively construct knowledge and (iii) comprehensive curriculum plan for all students. Below is the extract of the assessment summary from CEATE Assessment Panel:

"The awarded teachers are enthusiastic for their work. To achieve the goal of nurturing young talents, the Board of Science has been set up to develop the school-based Science curriculum which promotes scientific literacy among students on the one hand, and grooms the talent of the gifted students on the other. Such innovative school-based Science curriculum serves to provide students with extensive science research opportunities."

(p.54, http://www.ate.gov.hk/tchinese/doc/CEATE1617_Compendium_list_teaching_practices_award_SEKLA.pdf)

As a science educator, we are happy to see that everyone at school is starting to develop a new love for science. Even though not all of our students will become scientists in the future, we believe that science education has a role to play in nurturing all pupils to be informed citizens when they grow up. This is why we will continue to strive for excellence with our current science curriculum and further refine our teaching methods so that all of our students can develop an ongoing interest for science.

Development of Stem Cell Research Laboratory

Dr. SUEN Ka Chun, Head, Department of Biology and Biotechnology

Stem cells are unspecialized cells that are capable of self-renewing and differentiating into more mature cells with specialized functions (Institute of Medicine 2002; Smith 2001; Weissman et. al. 2001). There are generally two types of stem cells: embryonic stem cells and adult stem cells. Embryonic stem cells are derived from a very early-stage embryo which is called a blastocyst (Boston Children's Hospital website). Adult stem cells are undifferentiated cells which can be found in a differentiated tissue such as bone marrow (Institute of Medicine 2002). In 2006, there was a breakthrough that mature cells can be reprogrammed to become pluripotent stem cells (Takahashi and Yamanaka 2006). It is reported that the number of scientific research on induced pluripotent stem cell (iPSC) is significantly increasing. In 2006-2016, there were 3323 articles published for original research on iPSC (Negoro et. al. 2017). Stem cell research is believed to provide opportunities and development of regenerative medicine, although human embryonic stem cell research is ethically and politically controversial (Institute of Medicine 2002; Lo and Parham 2009).

Stem cell biology was not common in science education in many countries and was proposed to be taught in high schools in the United States in 2007 (Salli et. al. 2007). In Hong Kong, the topic of stem cells has been included in the new S.4-6 biology curriculum since 2007 (Education Bureau, HKSAR 2007). Yet, the concept of iPSC is not highlighted and no experiments related to stem cells are suggested in the curriculum guide. To help students acquire practical experience in stem cell experiments and research, our school is going to set up the Stem Cell Research Laboratory and enrich our existing school-based biotechnology curriculum with the topics about stem cells.

Secondary 2	• Types of stem cells and cell biology of stem cells • Stem cell therapy • Practical experiments on culture of stem cells (rat iPSC, to be mentioned below)
Secondary 3	• Research project (1 semester): Study of the differentiation of rat iPSC
Secondary 4-6	• Practical experiment: Study of the gene expression of neuronal markers by Polymerase Chain Reaction (PCR)
Programme for scientifically gifted students	• Research project: Study of the differentiation of rat iPSC by different types of traditional Chinese herbs; Study of the responses of rat iPSC to different toxins

To minimize concerns about ethical issues in stem cell research, our Stem Cell Research Laboratory will focus on mouse or rat iPSC. For example, students can study how rat iPSC can differentiate into brain cells and how to make these iPSC-differentiated cells to express functional proteins which can be found in ordinary brain cells. It is believed that this kind of practical experience can provide opportunities for students to develop interest and curiosity in science, achieving our school's mission to nurture informed citizens and breed young scientists.

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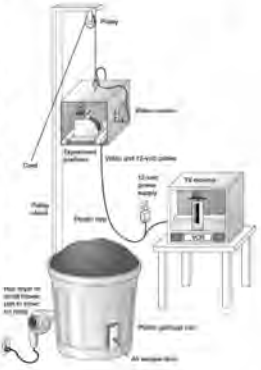
Development of Space Science Research Laboratory

Mr. WONG Yeung, Head, Department of Physics

Space science composes of many aspects related to physics, such as planetary motion governed by laws of gravitation, building telescopes for observing distant objects, investigating any variations of physical laws under a microgravity environment, understanding the propelling mechanisms for a rocket in terms of Newton's laws, the significance of spectrum for observing the universe. Many LFC students are interested in space science, especially after the success in the space science experimental design competition. Space science attract our students to overcome the barrier from DSE curriculum and carry out research on advanced physics in order to understand the phenomena in the Universe.

To incorporate the elements of space science in physics curriculum, students can realize that space science is also related to their daily activities. Junior forms students will learn motion graphs. The historic journey of Shenzhou involves launching of the spacecraft. Motion video analysis can be used to plot the graphs of displacement-time and velocity-time. Students can make use of the launching motion to study how the velocity of the rocket varies with time. For form 3 students who learn optics and electromagnetic waves, they can study the advanced applications of concave and convex lenses in building optical telescope to observe distant objects. Although the mechanism of telescope is out of syllabus in HKDSE, space science encourages our students to explore more in science beyond the scope of syllabus. Form 4 students who will begin learning Newtonian physics, building a water rocket helps our students learn how Newton's 3rd law is involved in the launching of the rocket. In space travel, a spacecraft performs frictionless motion according to Newton's 1st law. With an air track in the laboratory, students can observe an object moving nearly in constant velocity when its net force equals to zero. When the spacecraft returns to the Earth, it uses parachute to increase the resistance to make the spacecraft finally attaining a terminal speed for landing. To understand the landing processes of the spacecraft, a stroboscope lamp and video recording can be applied for a falling ball in a tube of oil so that the positions of the falling object at different instants can be taken.

Form 5 students learn orbital motion of satellites around a planet, with the help of a telescope and law of gravitation, the mass of Jupiter can be estimated by $T^2 = \frac{4\pi^2}{GM} r^3$. As a spacecraft moves around a planet in uniform circular motion, astronauts are in a microgravity environment. To understand that the normal reaction vanishes when the gravitational force is the only force for providing acceleration, a drop tower can be constructed. Its structure is shown in the diagram on the right. The data will be gathered during the drop experiment through a video signal. After the experiment, students can carefully analyze the video to see the effects of microgravity such as the zero reading of weight balance inside the experiment platform.



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Development of Food Science and Analysis Laboratory

Dr. TANG Wing Suen, Head, Department of Chemistry

Food is essential to our lives. However, the recent series of food safety problems has raised the awareness of food safety among the general public. In a review of food incidents in 2016, reported by the Centre for Food Safety of the Food and Environmental Hygiene Department, 29 % of the food incidents were due to the presence of chemical hazards such as the use of unauthorized or excess preservatives. The chemical hazard could result in the food being unsafe for consumption. In the food science and analysis laboratory, students will have the opportunity to conduct food analysis.

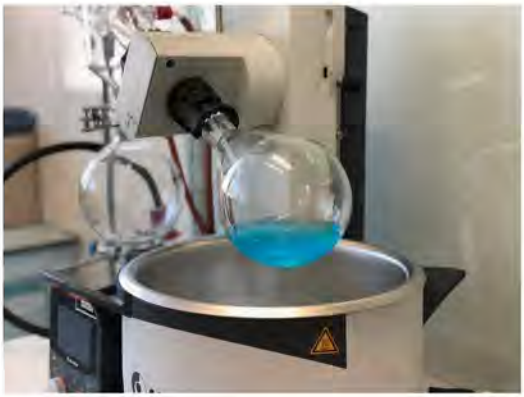
Food analysis can be conducted qualitatively or quantitatively in a school laboratory using chemical tests and techniques such as titrimetric method. During the investigation, students could realize the importance of conducting proper pre-treatment of samples, deciding suitable chemical tests, gaining hands-on experience using modern instruments, conducting data treatment and analyzing the results.

One of the areas of food analysis can be focused on chemical preservatives. Any food that may contain permitted food additives should not exceed the maximum permitted level as stipulated in the food regulation. The basic principle behind using chemical preservatives is to hinder the growth and activity of the micro-organisms and sulfur dioxide is one of these common preservatives used in the food industry. Titrimetric method can be used to determine the amount of sulfur dioxide present in dried food. Students could conduct a research investigation on the amount of sulfur dioxide present in the purchased dried food in order to assess whether the level in the food analyzed exceeds the maximum permitted level.

In the future development of the chemistry laboratory, equipping the laboratory with other modern instruments such as colorimeter and UV-VIS spectrophotometer could allow students to have more opportunities to conduct analyses on food samples. For example, (i) the identification of banned food colorings in food can be investigated by using chromatographic method; (ii) the amount of food colorings in drinks can be investigated by using a colorimetric method; and (iii) spectrophotometers can be used for the quantitative determination of the percentage of a food additive in a sample. More research projects could be proposed and conducted in the future with these sophisticated instruments.

The following content will be covered in Secondary 3 to Secondary 6 Chemistry curriculum in order to equip students with the necessary skills and knowledge to conduct the research projects.

Secondary 3	• Concepts and skills of qualitative analysis in analytical chemistry • Separation and purification methods • Tests for gases • Tests for the presence of metal ions, chloride ions and water.
Secondary 4	• Concepts and techniques of quantitative analysis in analytical chemistry • Mole calculations • Acid-base titration in titrimetric analysis • Tests for the presence of different kinds of cations and anions
Secondary 5 and 6	• Redox titration in titrimetric analysis • Tests for the presence of different functional groups in organic substances • Organic syntheses • Principles of colorimetric method and use of colorimeter • Modern instruments in chemical analysis • Principles and applications of chromatographic method in food analysis



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FROM SPARKING CURIOSITY TO SUSTAINED INQUIRY

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