Faculty of Science Newsletter
香港大學理學院通訊
www.hku.hk/science/news/newsletter.html | Published in April 2011

science@HKU

ISSUE NO. 11 第十一期

港理@HKU

Women in Science @ HKU

Professor V W W Yam

Professor D Yang

From The Editor

Dear readers,

You will find various important news in this issue of *Science@HKU*.

First, our earthquake, radiation and environment experts will discuss the recent magnitude 9.0 earthquake in Japan and its impact on the radiation safety.

Along another line, we know that it is the quality of work rather than one's gender that determines the level of success of a research scientist. This issue of ***Science@HKU*** reports on the secret of success as well as the determination to excel from some of our female colleagues in our Faculty.

This year also marks the 100th anniversary of HKU. We have set up a few interesting questions in the Brainteaser section concerning the historical facts of the Science Faculty HKU. See how many questions you can answer.

Yours sincerely,
Dr H F Chau
Chief Editor

Contents

Achieving research excellence has nothing to do with gender. In fact, women have made key contributions in science across all disciplines from its earliest days, though their efforts might not be illuminated and acknowledged generally in the past. The rise of women makes the role of female scientists in driving science forward more visible. This feature showcases our female teachers' dedication and achievements in scientific research, and the significance of their impacts. Just a few stories are told here, but we know many more deserve credits and recognition.

Female Teachers at the Forefront of Advances in Scientific Disciplines

If one is dedicated and determined to pursue research excellence, the hurdles can be overcome. The successful stories of Professor V W W Yam and Professor D Yang of Department of Chemistry are the best proofs.

Professor V W W Yam

Professor V W W Yam, Philip Wong Wilson Wong Professor in Chemistry and Energy, won the 2011 L'Oréal-UNESCO Awards For Women in Science (Asia-Pacific Laureate) for her contributions in light-emitting materials and innovative ways of capturing solar energy. More than 1,000 exceptional female scientists across the globe were involved in the nomination of the Awards' candidates, who come from five continents.

Professor Yam was privileged to receive the honour. "As long as one is devoted in research and enjoys the exhilaration of scientific discovery, one can definitely produce results of world-class quality, regardless of his or her gender," she said.

"I realize that many young women are worried about the barriers lying ahead in their career path, posed by possible gender stigmas. I hope that more successful stories of women would encourage them to pursue their dreams," Professor Yam added. As a typical Hong Kong educated and groomed scientist, Professor Yam has indeed set a role model for our young generation, demonstrating the strength and talents of women in scientific research and development.

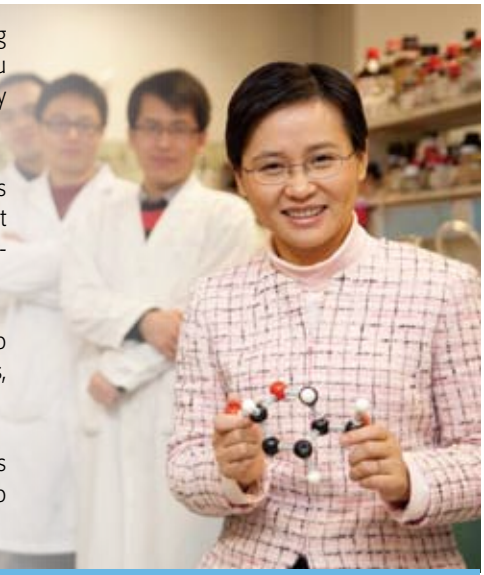
(photo courtesy: L'Oréal Hong Kong)

Awards and Achievements of Professor V W W Yam:

- L'Oréal-UNESCO Awards For Women in Science (Asia-Pacific Region) (2011)
- Hong Kong Outstanding Women Professionals and Entrepreneurs Award (2008)
- Hong Kong Fulbright Distinguished Scholar (2007)
- Fellow, TWAS, The Academy of Sciences for the Developing World (2006)
- Japanese Photochemistry Association Lectureship Award for Asian and Oceanian Photochemist (Eikosha Award) (2006)
- HKU Distinguished Research Achievement Award (2006-07)
- State Natural Science Award (2nd Class) (2005)
- Royal Society of Chemistry Centenary Lectureship & Medal (2005-06)
- Ten Outstanding Young Persons (Professional) of Hong Kong (2002)
- Member, Chinese Academy of Sciences (2001)
- Croucher Senior Research Fellowship (2000-01)
- HKU Outstanding Researcher Award (1999-2000)

Professor D Yang

Professor D Yang, Morningside Professor in Chemical Biology, was awarded the 7th Chinese Young Women in Science Fellowship and she is the first woman scientist in the Hong Kong and Macau region receiving the honour. She also received the TWAS Prize in Chemistry 2010 from The Academy of Sciences for the Developing World.



Professor Yang was honoured for her significant contributions to the development of novel methods for the synthesis of bioactive natural products and probes for biomedical research, which shed light on the study of cell growth regulation, immune responses and discovery of new anticancer, anti-inflammatory, and immunosuppressive drugs.

Professor Yang would like to share the joy with her research team members. "I hope students who have interest in research should pursue their interest, really put up efforts, carry out in-depth studies, and try to solve some real scientific problems," said Professor Yang.

As a research-led comprehensive university, HKU counts on the strength and capacity of researchers like Professor Yang. This has in turn helped to illustrate the University's vision and commitment to world-class research.

Awards and Achievements of Professor D Yang:

- 7th Chinese Young Women in Science Fellowship (2011)
- TWAS Prize in Chemistry (shared with Professor Santanu Bhattacharya of Indian Institute of Science in 2010)
- Eli Lilly Lectureship in Organic Chemistry, Massachusetts Institute of Technology, Cambridge, USA (2009)
- Novartis Chemistry Lectureship Award (2008)
- Eli Lilly Asian Scientific Excellence Award (2006)
- Ten outstanding Young Persons Award (2004)
- HKU Outstanding Researcher Award (2003)
- National Outstanding Young Scholar Award (2003-2005)
- Bristol-Myers Squibb Foundation's Unrestricted Grants Award in Synthetic Organic Chemistry (2001 - 2004)
- Croucher Senior Research Fellowship (2001-2002)
- Mr and Mrs Sun Chan Memorial Award in Organic Chemistry (shared with Professor Gregory C Fu at MIT in 2000)
- HKU Outstanding Young Researcher Award (1999)

To Be or Not to Be

by Fiona Shiu, PhD student and Research Associate in Department of Chemistry

A public seminar and the subsequent oral defense held at the beginning of year 2011 rounded off my four-year PhD studies. Sincere congratulations on my new title prompted me to fervently plan for my future career. Fortuitously, I was given the chance to visit three renowned women scientists in our Faculty. Both Professor M L Chye and Professor Y Sadovy work in the School of Biological Sciences whose research interests focus on plant molecular biology and marine sciences respectively. Dr P Chiu belongs to the Chemistry Department, and works on organic chemistry and total synthesis. I can say this experience was very thought-provoking and their words shed light on ideas to manage many of my uncertainties on the determination towards my vocation.

The first question that popped into my mind and interested me the most is for what reasons the three women started their career in academic research. It was surprising that Dr Chiu did not actually aim at becoming a professor when she was at school. "Even after PhD, I still planned to work in a pharmaceutical company." Dr Chiu recalled that she decided to enter academic research only after her post-doctoral studies. On the other hand, Professor Chye was stimulated by public lectures given by distinguished women scientists during her postgraduate studies. No matter when and how they had made up their mind towards doing academic research, a common characteristic of the three teachers motivated them to become what they are now: they were not salary-oriented; nevertheless they found interest in the subject they learned. "It was a romantic idea to work with animals under the water and travel all over the world. That was the life I wanted from a very young age," said Professor Sadovy.

Professor M L Chye

Though the three teachers have studied abroad, they were coincidentally attracted to come to Hong Kong and chose HKU to develop their research profession. Dr Chiu is of the opinion that compared with other universities overseas, HKU provides state-of-the-art electronic resources which are very important tools for academic research. Moreover, here we can always have productive manpower with strong work ethics. With the fact that HKU has been ranked 1st in Asia, "I had chosen HKU rather than other universities in Hong Kong even before the rankings!" asserted Professor Chye. Besides, Professor Sadovy, a pioneer in HKU fisheries, appreciates that Hong Kong people are developing a greater awareness of environmental protection that she believes is helped by teaching and research at HKU. Moreover, she values the freedom of expression possible in Hong Kong which is crucial for her research which often touches the controversial topic of conservation and management of marine life.

Professor Y Sadovy
(Photo courtesy: Stanley Shea)

Though the difficulties such as finding money and space for experiments are common for all researchers, it is not difficult to realize that the community of scientists is mainly composed of men. When asked about the particular concerns for women to consider when choosing academic research as a profession, all of the three teachers agreed that it was particularly difficult for women to strike a balance between family and work because the society has imposed expectations and prescriptions on the behavior of individuals in accordance with their gender roles. However, such a dilemma is not science-specific and it is the same for all women who work in a time-demanding career. Professor Sadovy commented that the challenges for women nowadays are higher up the hierarchy than before, "When you look at the top level, it still mainly involves men ." From her personal feeling and experiences, she explained, "particularly at the higher levels, things are often done through connections and men and women tend to communicate in different ways. Women may sometimes find it difficult to get to the top because they are often more direct in the way they express themselves and don't usually have the social or professional network that many men operate within."

To be or not to be. Scientists face a lot of challenges and yet can enjoy immense gratification and satisfaction in return. Apart from qualification and intellectual capacity on the research subject, what are other prerequisites to join this profession? Dr Chiu highlighted the importance of perseverance: "Most often things do not work. In research, to stop trying is equivalent to suicide." Significant results and progress only comes after a steadfast stream of efforts including trial and error. Therefore, academic researchers often work for long hours. "We do not work in a normal time frame of 9am to 5pm. Research is part of my life not something I switch off at the end of the working day; it is inspiring and exciting but needs dedication," said Professor Sadovy. To engage in scientific pursuit, Professor Chye gave the most profound remark "passion is the key."

Dr P Chiu

After the inspiring conversations with the three teachers, I feel more positive and committed towards my present research-based work. HKU is a good springboard for academic career. If your personality meets the nature of this profession, why not give yourself a try?

Hear from the Reporter

Shiu Hoi Yan Fiona

"Echoing many scholars I came across, HKU is the best university in Hong Kong. I am grateful that I can stay at this world-class institute for my undergraduate and postgraduate studies. Earnest thanks to HKU that it made my university life an unforgettably rewarding one. This is my eighth year in HKU. Working in my alma mater has been a good start at an early stage of my academic career. "Thanks, HKU!"

Passion and Perseverance Make One Go Further

by Disha Parikh, a Year 1 BSc (Biotechnology) student

In light of women scientists becoming more noticed in driving advances in scientific disciplines, I had an opportunity to talk with Dr A Yan and Dr N E Karraker from School of Biological Sciences recently, whose research interests focus on microbiology and environmental science respectively. My conversation with them was truly inspiring. In the pursuit of research excellence, both teachers have dedicated tremendous efforts on the research work undertaken, and this is one of the most difficult parts for young scientists. From them, I can see passion and perseverance, the indispensable keys of being a scientist.

Born in a family of teachers, it was just natural for Dr Yan to become a teacher. "The feeling of satisfaction and reward you derive from teaching and mentoring is beyond words" Yet, Dr Yan was not determined to be an academician until her late postdoctoral employment. "I used to question and struggle, but the picture became clearer after rounds of wondering. It was the people, especially my mentors, and things I met along the way reinforced my determination," Dr Yan continued. Her passion and enthusiasm for research grow as days pass by. "Now I'd say that is the career path I want to exactly dedicate to!" she said in a firm tone.

Dr A Yan

Dr Karraker's perseverance can be best illustrated by the fact that her field work requires her to work at night in forests and streams. Fascinated by venomous snakes, beautiful night owls and many other wild animals, Dr Karraker puts aside the risk of nocturnal work and diseases, spending her time studying amphibians and reptiles and doing research on biodiversity in very remote areas of Southeast Asia. "I got dengue fever in Indonesia last summer, and I have been bitten by snakes many times. These are challenging aspects of my work, but they are worth it for the biodiversity I get to see and the places I get to work." It is Dr Karraker's affection of mother nature and her wish to educate young generation that drive her forward.

Dr N E Karraker

I came to realize that the two teachers do not only excel in their own disciplines of expertise, but are also dedicated in their teaching at the university. Not only are they very knowledgeable in their field of work, their belief in education also fosters an interactive learning environment. "Teaching at HKU is indeed a challenging yet interesting and rewarding experience," said Dr Yan. As one of her students, I can assert that she is indeed very true to her word.

Traditionally speaking, science and related fields of study are considered to be male dominated, where females are not able to obtain the same level of recognition. However, both of the teachers share the view that although this has been the case, it is all about an attitude that one develops. Dr Karraker strongly encourages equality between sexes, especially during field courses. "Some people in Hong Kong think that field work, especially at night, is too strenuous and dangerous for women here. My female undergraduate and post-graduate students have soundly proven them wrong. Field research is not only for men and I hope more people come to this understanding in the future." she said. Dr Yan feels that being one of the few females in the field is empowering, rather than an obstacle. "Frankly, I don't see it as a disadvantage. In fact, I take it a precious opportunity to encourage my students, asking them to turn negative to positive," the optimistic teacher said.

Upon asking them about their message to future students in science disciplines, whether male or female, both responded with highlighting the pursuit of satisfaction. More specifically, Dr Karraker is keen to raise public awareness about conservation of biodiversity and Dr Yan is very encouraging by pointing to perseverance as the key to success. My conversation with them has been enlightening and I am encouraged their perseverance in research and fieldwork. This quality of positivity is something important that I should learn. I have become even more motivated towards my own career in biotechnology, as I am looking at a research oriented career in the future. All in all, I am grateful to be able to learn from them.

Hear from the Reporter

Disha Parikh

"As an international student, the question "Why HKU?" just popped up in my mind when I talked to the two teachers with diverse background. I grabbed the chance to ask about their thoughts. Both teachers indicated that the global environment, multi culture and availability of resources on research keep them here. As a non local freshman during my university application process, I too had found myself asking, "why HKU?", and can gladly say that I echo their opinion."

Celebrating the Achievements of Chemistry

By Dr P Chiu, Department of Chemistry, Co-chair, IYC 2011 HK

The International Year of Chemistry 2011 (IYC 2011) is a worldwide celebration of the achievements of chemistry and its contributions to the well-being of humankind. In declaring IYC 2011, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) recognized that an understanding of all matter and energy requires knowledge at the molecular level. Therefore chemistry is key to our understanding of the world and the cosmos, and chemistry will play an indispensible role to promote economic development and a sustainable world. Under the theme "Chemistry—Our Life, Our Future", IYC 2011 intends to raise public awareness and appreciation of the central role that chemistry plays in every facet of modern life. The year 2011 also coincides with the 100th anniversary of the Nobel Prize awarded to Madame Marie Curie, and the 100th anniversary of the founding of the International Union of Pure and Applied Chemistry (IUPAC), to provide an occasion to to celebrate the contributions of women to science, and to highlight the benefits of international scientific collaboration.

Locally, IYC 2011 Hong Kong is co-organized by the six tertiary institutions, partnering with the Education Bureau of HKSAR, Hong Kong Education City, Hong Kong Association for Science and Mathematics Education, the Hong Kong Chemical Society and the HK Chapter of the American Chemical Society. Chemistry research in Hong Kong is well-accomplished and recognized internationally,* so there is much to celebrate, and a strong and established tradition to pass on to our future students.

All of the tertiary institutions will be organizing events in this year to promote interest and education in chemistry to celebrate IYC 2011 Hong Kong. At HKU, a Chemistry Week will be held in September 2011.

Chemistry is often erroneously viewed as "polluting" by the public. In fact, chemistry itself is not the source of pollution, it is poor management of it that results in environmental problems. Therefore the prudent management of a sustainable environment will require a good grasp of chemistry by our students today in order to take care of our planet tomorrow. Chemistry has grown from the traditional sections of organic, inorganic, physical and analytical chemistry to encompass a growing scope with applications to materials, sensors, environmental management, medicine, and biology. In this field, chemists study not only the natural processes, but can create previously unknown molecules and materials whose potential are unharnessed. Chemistry has already been working together with different disciplines to solve many kinds of scientific problems. There is something in chemistry for everyone!

▲ The HK Chemistry Olympiad Champions – HKU!

The Opening Ceremony of IYC 2011 HK in February 2011 was attended by over 150 chemists, teachers and students from the six universities, local secondary schools, educational and professional organizations.** The masters of the ceremony were Gloria Fung (HKU BSc Year 2) and Jeff Chiang (HKU BSc Year 2). In addition to launching IYC 2011 HK, the awards for the 22nd Hong Kong Chemistry Olympiad for Tertiary Institutions Olympiad were also announced and presented on this occasion. The champion of this year's competition was our team from The University of Hong Kong! Our Olympians, Alan Kai Chung Yeung (BSc Year 3), Christy Oi Ying Hung (BSc Year 1), Heidi Li Ki Fu (BSc Year 2), together with a strong and spirited supporting team of chemistry students led by Dr Xuechen Li, Dr Angela Tong and Dr Ella Wong, seized the first prize by a talk on "HKUtopia", which showed how chemistry could be applied to the design of energy conserving and environmentally benign homes of the future.

Some important links:
IYC 2011 Official Website:
http://www.chemistry2011.org/

IYC 2011 HK Website:
http://www.hkedcity.net/iyc2011/

◀ The Chemistry Olympiad winning team

▼ The IYC 2011 HK Opening Ceremony

* *In 1993, Hong Kong ranked 14th in the world by cites per paper according to Science magazine [Bradley, D. Science (1993) 260, 1738]; according to SCImago Journal and Country Rank, in 1996-2009, chemistry in Hong Kong ranked 7th in the world for citations per document for countries/regions which produced at least 100 research papers.*

** *A report on the IYC 2011 HK Opening Ceremony appeared in the American Chemical Society's journal, Chemical and Engineering News: http://pubs.acs.org/cen/news/89/i10/8910news1.html*

Earth's Tectonic Plates and Japan's Catastrophe

by Dr J Ali, Department of Earth Sciences

The devastating events that happened in northern Japan on the afternoon of Friday March 11, 2011 are a sobering reminder of how violent our supposedly benign Blue Planet can be, and how fragile our society and constructions really are. The Monday March 14 edition of the South China Morning Post summed it up: "Japan's worst crisis since 1945, Kan says", Mr Naoto Kan being the Japanese Prime Minister. In this article, we will look into the basic processes associated with tectonic plates, and how these processes resulted in the Japan's catastrope.

Fig. 1. Earth ~100 million years ago. Note the narrow Atlantic, the Indian sub-continent sat next to Madagascar at ~45°S, and Australia and Antarctica were connected (source Ron Blakey, http://www2.nau.edu/rcb7/105moll.jpg)

Tectonic Plates Constantly in Motion

A team of aliens surveying the Solar System would, on completing their checklist of characteristics, note several distinguishing features associated with Planet Earth: an atmosphere, three oceans, numerous seas and several continents; water in its three forms: solid, liquid and gas; its equable temperature; its tilted rotation axis, which generates our seasons; its dynamo-generated magnetic field, which tells us a huge amount about Earth's internal machinations; and, of course, its complex life.

If our visitor's census was a follow up to one carried out a hundred million years earlier (Fig. 1; Earth is 4.5 billion years old) they would, however, be confused. Where mountains now exist (e.g. Himalaya-Tibet) there were previously none. Most land would be in the northern half of the globe; earlier South America, Africa, India and Australia were much further south. The Atlantic would be thousands of kilometers wide when before it comprised two barely connected "seas". The Pacific Ocean, which covers about 30% of the planet, would have shrunk by a quarter.

Fig. 2. Earth's tectonic plates. Their boundaries coincide with high earthquake activity and/or volcanism. Note that plate configuration for offshore SE Asia and the western and southwestern Pacific is highly simplified (source: US Geological Survey).

It is the dynamic nature of our planet's surface, and the process of "plate tectonics", that sees our oceans and the continents in a slow, steady waltz. Although their motions are imperceptible, typically a few to several centimeters per year (our fingernails grow at ~25 mm/year), the dance is not an easy one. Where the plates meet, there is inevitably friction and sometimes collision (e.g. Himalayas, Taiwan).

A map showing the distribution of earthquakes around the globe is telling that the pattern is not random; specifically the tremors are largely restricted to narrow belts. The volcanoes show a similar distribution, and it is these two sets of data that help us define the boundaries of Earth's tectonic plates (Fig. 2). Those associated with the most intense earthquakes, say, magnitude 7 or higher, are almost invariably ones where an oceanic tectonic plate is being forced beneath a continental one, a process geoscientists call "subduction". This is the case in Japan, as well as the much of the Pacific rim, including Chile, which as recently as February 2010 experienced a magnitude 8.8 shock. Subduction zones form part of a huge conveyor belt type system that recycles back into the mantle oceanic crust generated at spreading ridges. Subduction zone earthquakes, which result from friction between the overriding plate and down-going slab, are largely generated at depths of a few to several tens of km. As a subducting plate sinks deeper into the mantle, the heat and pressure reduces its rigidity (like a melting chocolate bar) and so the journey after it reaches ~100 km depth becomes a much more relaxed affair, and the earthquake activity tails off.

Plate tectonics will continue to operate until Earth's nuclear-powered internal heat engine splutters to a halt, or the Sun turns into a red dwarf and engulfs us. As neither are not going to be for billions of years, we are just going to have to live with earthquakes and their associated tsunami, unless we can persuade our alien visitors to take us to somewhere even better, although I think most of us would be reluctant to give up on our staggeringly beautiful Blue Planet.

Japan Earthquake & Tsunami

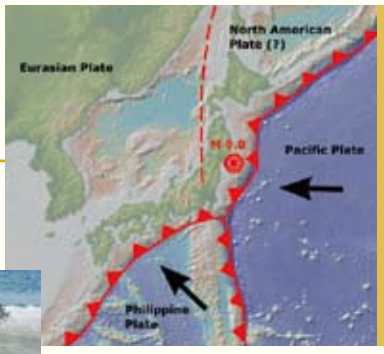


Fig. 1. Map showing location of the 11 March magnitude-9 earthquake and the regional tectonic configuration. The Pacific and Philippine Sea plates are both subducting beneath the eastern edge of the Japanese archipelago. Also, the Pacific plate is subducting beneath the Philippine Sea plate. Source: Scientific American affiliated website.

Fig. 2. Picture of the advancing Japanese tsunami

Famous for its tremors, the magnitude-9 earthquake was the largest one ever recorded in Japan. Although direct structural damage from the massive jolt seems to have been relatively minor, the tsunami (literally "harbor wave") train that smashed into northeast Japan's Pacific coast was devastating. Such was the power of the incoming mass of water, several small and medium size towns were ostensibly wiped from the map.

Tsunamis are regularly occurring phenomenon, but it was the Boxing Day 2004 catastrophe in western Indonesia that brought this type of natural hazard to the forefront of global consciousness, due to its impact on huge numbers across the Indian Ocean. In total ~230,000 people in fourteen countries lost their lives following that magnitude-9.3 event.

Earthquake-induced tsunamis are triggered when years or even decades of accumulated tectonic stress on a major fault a short distance below the sea-bed is suddenly released. The rapid movement of the sea-floor immediately displaces vast volumes of water, and as the liquid attempts to reach equilibrium, it moves out from the rupture area, often in waves that are barely noticeable (perhaps tens of centimeters or a metre). However, as the wave approaches a shore, or worse still a narrow section of shore bounded by prominent headlands, the wave front that rears up can grow to many metres. It is worth reminding ourselves that one cubic metre of sea-water has a mass of ~1025 kg, and so the advancing wall is unstoppable to all but the sturdiest of structures.

Japan sits on the northwestern sector of the so-called "Ring of Fire", a massive seismogenic belt that encompasses almost the entire rim of the Pacific Basin. In Japan, the earthquakes are generated by two tectonic subduction systems (Fig. 1), the one to the south-west involving the Philippine Sea plate, the other to the north-east the Pacific plate. The March 11 event was along a fault associated with the latter, which many experts had considered low-risk. In recent years, the SW system has received considerable attention with expensive drilling operations through the Nankai Trough fault zone. In contrast, not nearly as much work has been carried out on its northeastern counterpart, presumably because this area has a lower perceived earthquake risk and is somewhat less densely populated.

Some facts associated with the Japanese quake: the largest event "scientifically recorded" in Japan, globally the fifth largest since 1900; largest waves were at least 10 m high (Fig. 2); the quake was felt in Beijing, 2,200 km away; the tsunami reached Antarctica and California; at the time of writing, the death toll was predicted to be around 20,000; close to half a million people have been displaced; young children and old people were disproportionately affected as they were less able to escape the advancing water; the World Bank estimates that the total cost of the disaster could be US$ 235 bn.

Perhaps the one message humanity can take from this event, and the Indonesian one of 2004, is if you find yourself in an area with an earthquake-tsunami potential, no matter how unlikely it is for you to be affected, make yourself aware of the hazard and follow very closely any advice/guidance that is given. It could save your life.

About the Writer

Dr J Ali is an Associate Professor of the Department of Earth Sciences. A significant component of his research is directed towards understanding plate tectonic processes. As a post-doctoral fellow, he worked on the Philippine Sea plate, publishing four key papers in 1995. In the last decade, he has focused on mountain building in Tibet and the Himalayas, which has resulted from India colliding with Asia. Following the recent Japanese disaster he appeared on the TVB's Pearl Report talking about the earthquake hazard in China and its potential impact on the country's nuclear-power programme. (http://mytv.tvb.com/news/pearlreport/116838/#page-1)

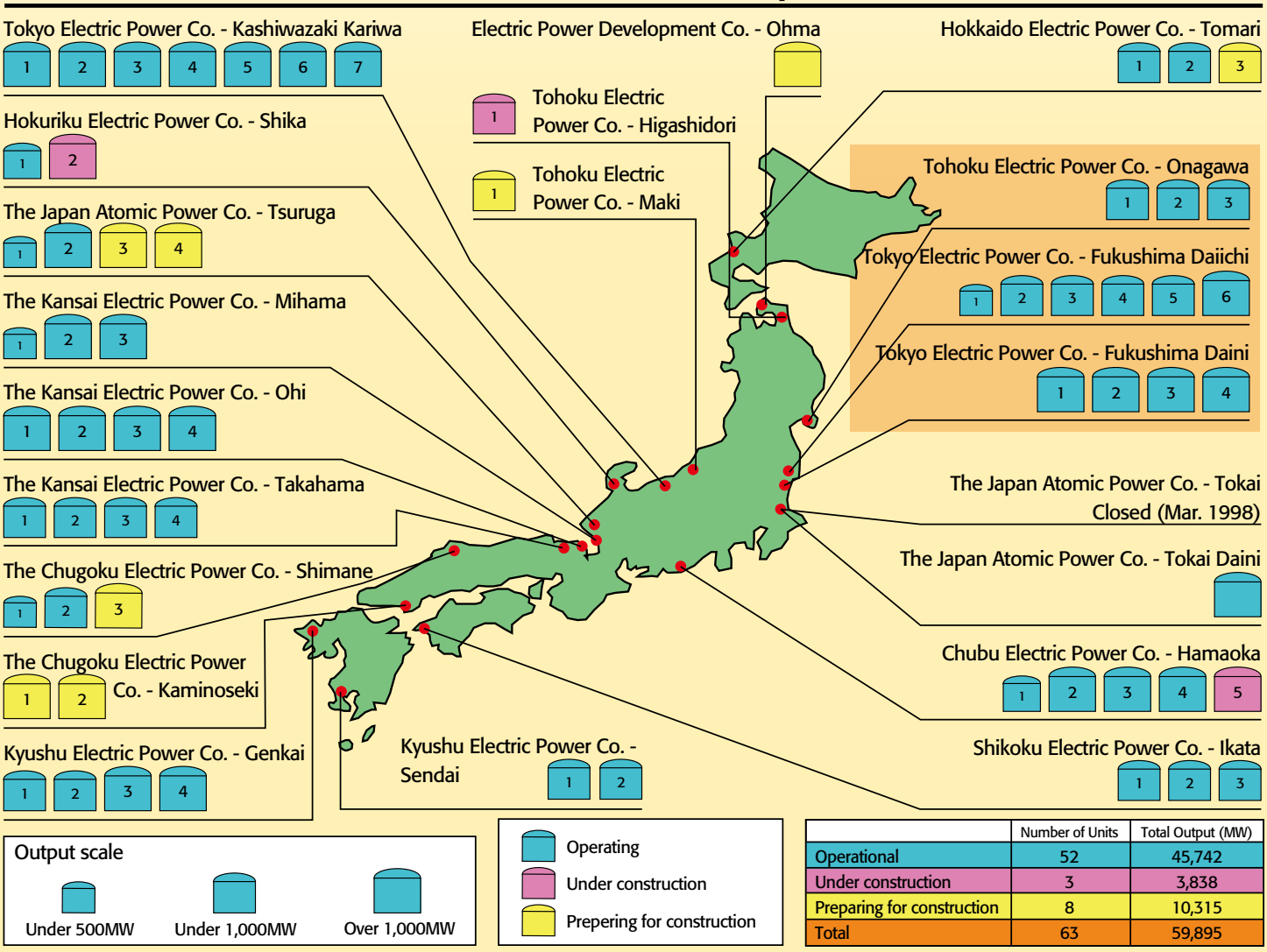
Nuclear Crisis of Fukushima Dai-ichi Nuclear Power Station in Japan

by J KC Leung, Department of Physics

The earthquake and the subsequent tsunami that occurred in Japan on March 11, 2011 have not only shattered many homes and families in Japan, but also rocked the nuclear power industries throughout the world. After the earthquake, a total of 10 reactor units in 3 nuclear power stations along the eastern coastline of Japan were automatically shutdown. The 3 stations were Onagawa Nuclear Power Station, Fukushima Dai-ichi Nuclear Power Station and Fukushima Daini Nuclear Power Station. There were 3 other units in Fukushima Dai-ichi Nuclear Power Station that were already shutdown for regular inspection. Despite of the shutdowns, the crisis in the Fukushima Dai-ichi reactor units continued to escalate, eventually leading to off-site release of radionuclides into the environment. This article tries to explain the physics behind this nuclear disaster and look forward to lessons that could be learnt.

Nuclear power stations generate electricity by using heat produced in uranium fuel in the core of the reactor to raise steam to drive conventional turbine generators. Fission energy is released when a ^{235}U nucleus absorbs a slow moving (thermal) neutron, resulting in splitting of the ^{235}U nucleus into 2 smaller nuclei (fission products) plus a number of neutrons. Since the neutrons are light compared to the fission products, almost all the fission energy is carried by the neutrons which are thus emitted at high velocity. These fast neutrons will leave the fuels rods and collide with water that is flowing through the fuel rods. Through colliding with the water molecules, in particularly the hydrogen nuclei, kinetic energy is transferred to the water molecules and the fast neutrons slow down. This process is called "moderation" and the water is thus heated up. The thermalised neutron is then ready for capture by another nearby ^{235}U nucleus to continue

Nuclear Power Plants in Japan



	Number of Units	Total Output (MW)
Operational	52	45,742
Under construction	3	3,838
Preparing for construction	8	10,315
Total	63	59,895

the "chain reaction". The rate of fission is controlled by inserting boron control rods between the fuel rods to absorb the neutrons. In a complete shutdown, the control rods are fully inserted.

There are only a handful of naturally occurring radionuclides that can undergo nuclear fission with ^{235}U as one and ^{239}Pu as another. ^{235}U co-exists with other uranium isotopes in the ratio of $^{234}U : ^{235}U : ^{238}U \sim 0.006 : 1 : 99$. This concentration of ^{235}U in un-enriched uranium is insufficient to sustain a nuclear chain reaction. Uranium fuel suitable for nuclear reactors must contain about 3% ^{235}U, that suitable for weapons must be enriched to over 90%. Incidentally, the difference in enrichment is one of the fundamental reasons why a nuclear explosion in a nuclear reactor cannot physically happen.

Fission products build up steadily inside the fuel pellets in fuel rods while the ^{235}U is consumed and the efficiency of fuel use decreases. Some of the fuel rods must therefore be replaced at regular interval, usually during an annual shutdown. The discharged "spent" fuel contains about 95% unused uranium (~1.5% of ^{235}U), 1% ^{239}Pu formed from ^{238}U through the breeder reaction ($^{238}_{92}U + n1 \; ^{239}_{92}U \xrightarrow{\beta} {}^{239}_{93}Np \xrightarrow{\beta} {}^{239}_{94}Pu$), and 4% fission products which constitute wastes. The fission products will continue to decay and emit radiations even though the chain reaction is stopped. Hence the spent fuel has to be kept cooled in the spent fuel pool for a certain period of time (more than a few months) to allow decay of short-lived fission products. They will then either be disposed of, or reprocessed to separate unused fissile materials from waste products that have no practical use. If spent fuel were to be reprocessed, the residual ^{235}U and ^{239}Pu would be chemically recovered and processed to form a mixed oxide (MOX) fuel for production of energy in thermal reactors. Some recovered ^{238}U can be re-used in fabricating new uranium fuels while some recovered Pu oxide can be used as fuel for production of ^{239}Pu in fast breeder reactors, the latter being a specially designed reactor.

The Fukushima Dai-ichi reactors are boiling water type reactors, in which water is used both as the coolant and moderator. It consists of 2 coolant systems: the primary coolant that absorbs the fission energy and boils inside the reactor and the generated steam is directed to turn the turbine generator which is located outside of the reactor vessel. The steam is then cooled by the secondary coolant system which uses sea water. When the tsunami hit the Dai-ichi power stations, all the reactors were already shutdown. However the earthquake has damaged some local electricity network and coincidentally the backup diesel generators were destroyed by the tsunami, the reactor units started to enter the loss-of-coolant accident one by one. Loss-of-coolant accident is one of the most severe accidents that could occur in nuclear power plants and its designed-based occurrence rate should be less than 1 in 10 million years. Clearly the Dai-ichi power stations, which were built some 40 years ago, were not designed to meet the magnitude of earthquake and tsunami that they faced recently. When the coolant systems stop circulating, the water temperature inside the reactor vessel will rise due to decay heat of the fission products. More steam will be produced and the pressure will rise. When water drops to below the fuel rods, the exposed fuel rods can rise to very high temperature such that the zirconium casing of the fuel rods will act as a catalyst that turns steam into hydrogen and oxygen. The leaked hydrogen that filled the containment buildings of unit 1 & 3 eventually exploded and disrupted the roofs of the buildings. Some ^{3}H was released in the explosions. ^{3}H is a cosmogenic radionuclide that occurs naturally. It is generated continuously in nuclear reactors and is allowed to be released into the atmosphere within a restricted quantity per month. Loss-of-coolant accident also occurred in the spent fuel pool of Unit 4, resulting in steam and hydrogen build-up that eventually exploded.

The situation got worse when ^{131}I and ^{137}Cs were detected in air. These radionuclides are fission products with yields of 2.9% and 6.4% respectively and normally they are sealed inside the fuel pellets. Their presence in the atmosphere indicates that some fuel pellets and fuel rods have melted and the gaseous elements have escaped. ^{131}I exists in gaseous form at high temperature while the parent nuclide of ^{137}Cs is ^{137}Xe, which is a gas. Both ^{131}I and ^{137}Xe have half-lives (8.02 days and 3.81 min) long enough for them to leak from the reactor vessel to the environment. ^{137}Xe then decays into ^{137}Cs after dispersal by the wind. So far, no other solid radionuclides were detected, showing that both the melt-down and the leaks are not very severe.

It was reported on the day of writing this article that the power company has successfully controlled the temperature of the reactors and kept them at cold shut down situation. As long as the uranium fuels are maintained at sub-critical condition and no chain reaction can occur, it is hoped that the residual decay heat will subside in a few months' time and no more fission products will be released.

Naturally Hong Kong people are worrying about whether similar crisis can happen in Daya Bay nuclear power plants. I believe the chance is very small because there are a number of inherently different conditions between Daya Bay power plants and Dai-ichi power plants as summarized in the table below.

Fukushima Dai-ichi power plants	Daya Bay power plants
Boiling water type reactor with 2 coolant systems: contaminated water in the primary coolant has higher chance of leaking to the outside	Pressurized water type reactor with 3 coolant systems: contaminated water has less chance of leaking to the outside
Older technology and lower safety standard. E.g. control rods inserted from bottom; backup pumps not secured	Newer technology and higher safety standard. E.g. control rods inserted from top that can drop by gravity during power outage; chain reaction can also be stopped by injection of boronic acid; more redundancy for backup pumps and systems
Higher chance of being attacked by earthquake and tsunami	Much less chance of being attacked by earthquake and tsunami

About the Writer

Dr J K C Leung is an Associate Professor in the Department of Physics and is also the University Radiation Protection Officer in the Safety Office. Dr Leung's major research is on radiation protection and environmental radioactivity as well as high energy and particle physics. He has been the Chairman of the Hong Kong Radiation Protection Society and a Member of the Radiation Protection Advisory Group of HKSAR under the Daya Bay Contingency Plan. Currently he serves as a Scientific Advisor of the Hong Kong Observatory and the Responsible Person (Radiation) of the Siu A Chau Low Level Radioactive Waste Storage Facility.

Law of Small Numbers

By Dr P L H Yu, Department of Statistics and Actuarial Science

Suppose you are now on a bus. A passenger gets off the bus and leaves an iPad on a seat. You pick up the iPad and would like to contact the passenger by dialing '9' first and then 7 random numbers (here we assume that all mobile numbers start with the digit 9 and the passenger has a mobile phone). Of course, most people think that such an action is ridiculous as the probability of contacting the passenger is only 1 in 10,000,000. However, we can see many people engage in nearly hopeless activities such as buying a single entry of Mark Six Lottery hoping to choose the six drawn numbers (from 1 to 49) correctly. Such winning probability is only 1 in 13,983,816, even smaller than that of contacting the owner of the iPad. Worse still, the 2007.8.18 issue of the *Economist* mentioned that "Goldman Sachs admitted as much when it said that its funds had been hit by moves that its models suggested were 25 standard deviations away from normal. In terms of probability, that translates into a likelihood of 0.000...0006, where there are 138 zeros before the six. That is silly". All these provide evidences of uncertainties in our lives.

In observing a phenomenon of uncertainty, its outcome is always haphazard and is often not predictable. More examples include tossing a coin, forecasting weather, detecting an earthquake, investing in a portfolio of stocks, etc. Although the outcome looks like random, it in fact follows a famous law in probability: the law of large numbers. According to the law, when conducting the same experiment a large number of times, the proportion of an event will converge to a stable value which represents the theoretical probability of occurrence of the event. For instance, in tossing a fair coin many times, it is expected to observe heads in 50 percent of times.

The law of large numbers was first proved by Jacob Bernoulli in 1713 and laid a very important foundation for the development of statistics. For example, we would like to know whether Financial Secretary John Tsang should revise the 2011-12 Budget by conducting an opinion sample survey collecting people' views on the Budget revision. With the law of large numbers, as long as the sample is large enough, the sample proportion of people who are in favor of the Budget revision should accurately reflect the true proportion of such people in the entire population of Hong Kong.

Note that the sample proportion accurately reflects the probability only when the sample is sufficiently large. However, some people may not be able to grasp the 'law of large numbers'. They generally have a misconception that in small samples, the sample proportion should also be close to the true proportion. In 1971, two psychologists, Daniel Kahneman (who received a BSc with a major in psychology and minor in Mathematics) and Amos Tversky (a cognitive and a mathematical psychologist), called this judgmental bias as the 'law of small numbers'. They discovered that people are not always rational, and they may act irrationally in making decision under uncertainty. Very often, people tend to rely on their own insight or limited experience to make inference, hence violating the law of large numbers.

Imagine that you observed the following sequence of 200 heads (H) and tails (T):

H H H H T T T T H H H T T T H H H H T T H H T H H H T T T H H T T H H
H T T T T H H H T H T H H H H H T H H T H H T H H H H H T T H H T T
T H T T H T H T T T T H H H T T H H T H T H H T T T H H T H H T T H T
H T T H T H H H T H T H H H H T T T T H H H T T H H T H T T H H H T H
H H T T H T H H T T H H H T H H T T T T H H H H T T T H H H T T T T H
H H T H H H T H H H T T T T T T H H T T T H H T H H

Do you think that this sequence is generated by tossing a coin 200 times? Probably, you may answer 'No' when you observe a sequence of several consecutive heads or tails (says TTTTT). You may think that, after observing a few consecutive heads, it will have a higher chance to get a T in the coming toss since observing a T in the coming toss can bring the sample proportion of heads closer to 50%. This of course demonstrates a misunderstanding of randomness. In fact, the outcomes of tossing a coin many times are independent, and the probability of getting a T in each toss is always 50%. Because of such psychological bias, when the iPod first launched the shuffle feature which plays songs in a random order, many people complained that it is not 'random' enough. Apple CEO, Steve Jobs, eventually modified the software: 'We're making it less random to make it feel more random'!

The law of small numbers also appears in the financial market. When an investor observes that the stock price has risen for five days, he may think that it will have a greater chance for the stock price to rise on the sixth day. His underlying belief is that small samples replicate the probability distribution properties of the population. If investors invariably apply the law of small numbers, they will get into the market and invest on the sixth day after a rise of stock price for five days. Consequently, this action will create a buying pressure, which will lead to an increase of the stock price on the sixth day.

Let's use the Hang Seng Index from 1991 to 2010 to test for this conjecture. In the last two decades of the 4,973 trading days, Hang Seng Index rose in 2,580 days, thus the probability of rising in a day is 2580/4973 = 51.9%. In these two decades, Hang Seng Index rose for 5 consecutive trading days for 205 times, and 113 of them maintained upward trend on the sixth day. So the probability of continuing to rise on the sixth day is 113/205 = 55.1%, really larger than the chance of rising on a day (= 51.9%). Of course, the above preliminary analysis cannot prove that investors wrongly use the 'law of small numbers ' as the sample of 205 observations is not large enough to draw a significant conclusion. More sophisticated statistical analyses are available to address this problem. What we mentioned above reveals that we are living with uncertainty and statistics is a useful tool to study uncertainties. In fact, statistics can be found almost everywhere. Probably, you may not know that statistics have been used to predict Oscar winners, to study evolutionary change in *E. coli*, to explain why the reported "proven reserves" of oil and gas deposits throughout the world are always underestimated, etc. Due to limited space, I hope to introduce these interesting applications of statistics in the future.

Forum on New 4-year Science Curriculum

A Forum for Secondary School Teachers on the HKU Science Education in 2012 4-year Curriculum was successfully held on January 13, 2011, in which a total of 90 teachers from 65 secondary schools participated and exchanged information with the Faculty on the new HKU science curriculum. It provided a platform for the Faculty and secondary schools to discuss about key issues and challenges in the NSS Science Curriculum, and to enhance communication and collaboration between secondary schools and the University on Science education.

In the breakout session, University and secondary school teachers discussed the primary purposes, superior features, deficiencies and major challenges in teaching of NSS Science curriculum structure, the role the University could play to help teachers and how University curriculum could redress the deficiencies. The major concerns of secondary school teachers regarding assessment and admission policy were also addressed.

The Forum was well received by participants. Over 73% of the respondents considered the Forum met the stated objective. 91% indicated it was worthwhile to attend the Forum. 80% would like to attend other programmes on the 4-year curriculum in future and 71% would like our Faculty members to visit their schools and introduce the new 4-year curriculum to teachers and students.

Brainteaser

Questions

One hundred years ago, the University was established. Although the Faculty is 28 years younger than HKU, it is also full of history. Let's see how much you know about the Faculty by completing the following quiz:

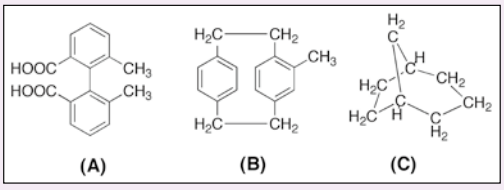
1 The Governor who joined us celebrating the Faculty's 50th anniversary.
2 The year that the Department of Earth Sciences was established.
3 The year that the Faculty office in Chong Yuet Ming Physics Building was opened.
4 An alumnus who was one of the most celebrated female Chemists of HKU Science in the 60's.
5 A lecture theatre named after an alumnus of the Faculty.
6 The longest serving Dean of HKU Science.
7 The Guest-of-Honour who officiated the Opening Ceremony of the Kadoorie Biological Sciences Building.
8 The year that the total number of HKU Bachelor of Science graduated each year surpassed 400.
9 The number of Science alumni who became Dean of HKU Science.
10 The number of Science alumni who became Vice-Chancellor of the University.

Prize: *Adrift – Tales of Ocean Fragility* by Professor Y J Sadovy and co-authors
Deadline: May 31, 2011

Please email your answer together with your name and school (for students), to scinews@hku.hk. FIVE winners will be drawn randomly from the contestants who give the correct answer.

Question of Last Issue's Quiz:

The synthesis, isolation, and characterization of chiral molecules are very important topics in organic chemistry. Two molecules with exactly the same molecular structure but with opposite chirality could have different properties. This is especially important for those molecules in biological systems (e.g. proteins) or those for pharmaceutical applications. Three molecules, A-C, are shown in the figure. Please identify which molecule(s) is/are chiral, and write a very brief explanation.



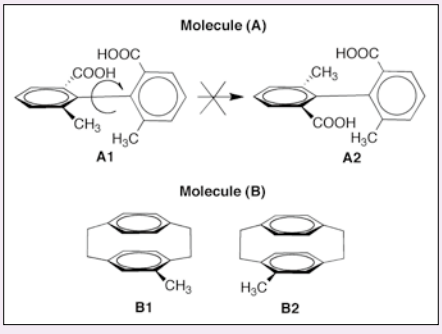
Answer:

Molecule A and Molecule B are chiral, while Molecule C is achiral. The correct structural representations of Molecules A and B are shown in the figure.

Molecule A is a substituted biphenyl molecule. The two phenyl groups in Molecule A are not coplanar because the methyl and carboxylic groups in each ring are too bulky. In addition, the C-C bond between the two phenyl groups cannot rotate freely for the same reason. Due to the restricted rotation, A does not have a plane of symmetry. Thus A1 and its mirror image A2 are enantiomers which cannot be interconverted to each other.

Molecule B belongs to a group of hydrocarbons called "cyclophanes". Due to severe geometrical constraints in the molecule, the two phenyl groups are not coplanar, but stacked as shown. As a result, it also does not have a plane of symmetry, thus enantiomers exist. As you can see, stereoisomer B1 is not superimposable on its mirror image B2.

Molecule C is achiral because it has an internal plane of symmetry, bisecting the molecule into halves.



ACHIEVEMENTS

University Awards

- **Professor B K C Chow** (first one from the right), Professor of School of Biological Sciences, shared the *Research Output Prize 2009-2010* with Jessica YS Chu, C H Lai, Leo TO Lee, H Vaudry, Y S Chan and W H Yung for their efforts on the research paper "*Secretin as a Neurohypophysial Factor Regulating Body Water Homeostasis*", *Proceedings of the National Academy of Sciences USA 106, 37(2009)*.

- **Professor H Sun** (on the left), Professor of Department of Chemistry, was granted the *Outstanding Researcher Award 2009-2010*.Professor Sun's research has recently focused on the structural biology of metallo-proteins, and on metallomics and metalloproteomics. By using chemical biology and metallomic approaches, his research team has identified several key metallo-drug binding proteins that provide a basis for mechanism-based drug design.

- **Professor Dr X Cui** (on the right), Associate Professor of Department of Physics, was granted the *Outstanding Young Researcher Award 2009-2010*. Recently, Dr Cui and his HKU colleagues conducted a series of experiments, for the first time, to quantitatively evaluate the strength of spin currents in a two-dimensional electron gas system, which has been an important but challenging topic in spintronics research.

- **Dr N K Tsing** (on the left), Department of Mathematics and Associate Dean (Teaching & Learning) of the Faculty, received the *University Distinguished Teaching Award (UDTA) 2009-2010* for his exceptional accomplishments in teaching and engagement with students and their learning, curriculum design, renewal and innovation. The UDTA introduced in 2009 is to recognize a teaching staff who has made outstanding contributions to the leadership and scholarship of Teaching and Learning at both University and Faculty level.

Faculty Awards

- **Dr K M Y Leung** (in the middle), Associate Professor of School of Biological Sciences, was given the *Award for Service Contribution 2009-10* in recognition of his devotion in serving the Faculty and the community. Dr Leung is actively engaging in teaching curriculum development, through serving undergraduate teaching committees at both Faculty and School level. Locally, he acts as an expert member in several environment-related committees for the Hong Kong SAR Government. Internationally, he is the President of the Society of Environmental Toxicology and Chemistry (Asia-Pacific Geographical Unit).

- **Dr A S T Wong** (on the right), Associate Professor of School of Biological Sciences, received the *Award for Teaching Excellence 2009-10* in recognition of her outstanding teaching performance and efforts in the curriculum design, review, and innovation both for the School of Biological Sciences and the new 4-year curriculum.

Lectures and Seminars

- November 2, 2010: Seminar – **"Planetary Boundaries: A Safe Operating Space for Humanity in an Era of Rapid Global Environmental Change"** by Professor Johan Rockström, Executive Director of the Stockholm Environment Institute and the Stockholm Resilience Centre. The seminar is co-organised withThe Hong Kong Jockey Club Charities Trust and Civic Exchange

- December 20, 2010: **Dialogue with Nobel Laureate: Professor Daniel Tsui**, Arthur LeGrand Doty Professor of Electrical Engineering at Princeton University, and Distinguished Visitnig Professor of the Faculty

Professor Daniel Tsui, first one from the left

- January 25, 2011: Public Lecture – "**Enhancement of Post-Secondary Science Education: Using Problems as the Vehicle to Learn**" by Dr Hsing Chi von Bergmann, University of British Columbia, Vancouver, Canada

- February 16, 2011: Lecture – "**From Reefs to Restaurants: the Hidden Cost of Luxury Seafood**" by Professor Yvonne Sadovy, School of Biological Sciences; organized by the Royal Geographical Society

- February 18, 2011: Public lecture – "**The Origins of Earth-like Planets**" by Professor Alex N Halliday FRS, Head of the Division of Mathematical, Physical and Life Sciences, Oxford University

- March 7, 2011: Faculty Centenary Lecture – "**Opportunities and Challenges In Developing Sustainable Biofuels from Cellulosic Plant Biomass**" by Professor Timothy Donohue, Director, Great Lakes Bioenergy Research Center, Professor of Bacteriology, University of Wisconsin-Madison

- March 17, 2011: Faculty Centenary Lecture – "**Carbon Dioxide and Global Change**" by Professor Yuk L Yung, Professor of Planetary Science, Division of Geological and Planetary Sciences, California Institute of Technology

- March 18, 2011: Centenary Distinguished Lecture – "**The Protein Universe and Daily Life**" by Professor Kurt Wüthrich, Recipient of the Nobel Prize in Chemistry in 2002

For details: please visit www.hku.hk/science

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