DNA is the blueprint of life because of its role as the genetic material, and it plays pivotal roles in molecular biology. DNA molecules not only carry genetic information, but also serve as templates to direct the synthesis of messenger RNA, the subsequent translation enable nature to produce its highly versatile functional macromolecules, proteins, which are considered the machinery of life.

It is truly amazing to realize that DNA molecules can fulfill their important and complicated biological roles with rather simple structures which contain only 4 nucleobases: adenine, guanine, cytosine and thymine. The three dimensional structures of DNA molecules were unknown until 1953 when James D. Watson and Francis H. C. Crick first proposed DNA double helix structure. This concept is so firmly planted in our scientific lexicon that we can not remember a time when DNA was not recognized as taking the form of two hydrogen-bonding complementary strands of base-pairing nucleotides wound around a single axis.

From an evolutionary point of view, almost 4 billion years ago, nature made her selection to use nucleic acids as replicable information carriers. However, when the versatile biocatalysts were concerned, nucleic acids were not suitable in mediating the vast diverse chemical reactions in biological systems, probably due to lack of functionalities on nucleic acid molecules. Proteins were thus evolved to serve as functional molecules in biological systems, which are capable of generating biologically important small molecules with desired properties. Production of proteins and the desired small molecules ultimately depend on the super instructing power of DNA molecules.

One fundamental intellectual challenge in medicinal chemistry is how to generate molecules with desired biological properties. Despite the enormous advances of combinatorial chemistry, few drugs have emerged from this technology. Based on a recent statistical data, among the chemical entities introduced as drugs by the end of 2002, 61% are natural product related. Nature’s approach to discover natural products, as illustrated in Figure 1, is far more superior to our chemists’ approaches which are mainly painstaking synthesis and screening. What can we learn from nature in her elegant way of selecting genetic materials and functional molecules? Can we use the super instructing power of DNA to direct chemical synthesis? Some recent work started to shed light on the above questions.

In the so-called DNA-templated synthesis process, DNA was used...
as templates to carry out multi-step organic synthesis and construct library of small molecules. In this approach, starting materials are covalently linked to the DNA templates, while the reagents are similarly linked to the complementary DNA sequences. Upon Watson-Crick base pairing, the most powerful molecular recognition of nature is utilized to bring the reactive groups into close proximity to effect otherwise impossible reactions. The DNA template is a 30 to 100 nucleotide DNA single strand that comprises several short coding sequences. The linked substrates and reagents are of low nanomolar concentration thus off-template reactions are unlikely to occur. Complementary bindings of DNA strands raise the effective concentrations of reactants in the millimolar to molar range. Different coding regions are used to direct the chemical synthesis. Such DNA-templated synthesis has turned out to be quite general, and DNA has been shown to be able to direct the multi-step organic synthesis and the generation of synthetic small-molecule macrocycles.

“DNA display” uses DNA to segregate molecules to carry out “split and pool” synthesis in order to generate small organic molecules with great molecular complexity. A library of DNA oligomers is constructed, each containing a number of coding regions. Figure 2 shows one of such DNA oligomers. Each coding region uses hybridizing power to direct the DNA oligomers to visit specific complementary sites, where the small molecules at the end of DNA oligomers will react with chemical groups at the site. A library of 1 million nonnatural peptides has been prepared by DNA display.

DNA-templated synthesis and DNA display are still at their early developing stages, more and more such thrilling chemistry is expected to come. The true excitement of DNA-directed synthesis is the potential realization of molecular breeding - application of the evolutionary principles used by nature to the discovery of novel agents with desired properties. If mutations of the coding DNA sequences can generate a vast number of molecules with great diversity, they can compete with each other to evolve the best molecules with given desired properties – this Darwinian process can lead to a brand new era in chemistry.

Figure 2: one DNA oligomer for DNA display

2nd Chemistry – IMRE Joint Symposium

The 2nd NUS Chemistry-IMRE Joint Symposium was held at the IMRE auditorium on November 25, 2004. Researchers from both organisations attended talks, poster presentations and discussions on materials-related research. The symposium was opened by Professor Lee Hian Kee and Dr Lim Khiang Wee, Executive Director of IMRE. Six speakers from each organization were invited to speak on the latest research progress in fabrications, characterizations and applications of materials. 125 participants attended the symposium, 87 of whom were from NUS and IMRE, while 38 from industries and others. Representatives from companies included chief technical officers, managing directors, R&D managers and engineers from local and international companies such as Sumitomo Bakelite, ST Engineering, Qualitek Singapore, Zugo Photonics and Hyflux Ltd. The symposium ended with a close-panel discussion, in which a student co-development programme was proposed, among other topics of interest. It was a successful symposium, with much thanks to co-organisers, Dr Toh Chee Seng (NUS Chem) and Dr Chen Zhi Kuan (IMRE), as well as supporting staff from both organizations, and not to mention, good food and logistical support provided by IMRE.

Dr. Lu Yixin studied chemistry and received his B.Sc. from Fudan University at Shanghai. He carried on to pursue his graduate studies in Canada and obtained his Ph.D. in organic chemistry from McGill University in 2000. After postdoctoral appointments at the Clinical Research Institute of Montreal, and also at the Research Center for Materials Science at Nagoya University, Dr. Lu went to USA and worked at Locus Pharmaceuticals. Dr. Lu joined NUS in September, 2003. His research mainly focuses on Organic and Medicinal Chemistry. His current interests include the development of asymmetric synthetic methodologies and the preparation of therapeutically useful agents. In his spare time, Dr. Lu enjoys sports, dining and traveling.

Poster presentations (top) and talks (above) were well received by the participants at the symposium.
The 3rd Singapore-India Collaborative and Cooperative Chemistry Symposium
Indian Institute of Technology, Kanpur, India, December 16-17, 2004

Following the 1st SInCCCS initiated by our Department held in Singapore during December 2-3, 2002, the second SInCCCS was organised and held at the Department of Chemistry, IIT-Bombay, Mumbai, India during November 7-8, 2003. At 2003 meeting, the decision was made for the University of Hyderabad to host the third symposium. Tragically, Professor Baskara Maya who was to organise it, passed away in 2004. Professor P.K. Bharadwaj of the Department of Chemistry, IIT-Kanpur, then offered to organise the event in order to maintain the initiative and continuity. He was assisted by young assistant professors of his department, Drs J.K. Bera, G. Anantharaman and M.L.N Rao.

Ten members of the NUS-Chemistry delegation, led by Head of Department Professor Lee Hian Kee, were invited to participate and present lectures at the symposium. The IIT campus was spacious and impressive with a lot of greenery, very much similar to all other IITs. The roads were wide and lined with trees, and wild peacocks and peahens were seen everywhere, a feature of this campus (IIT-Bombay is well-known for its leopards, for example!). We were warned that where there were peacocks and peahens, there were snakes (venomous cobras and kraits); fortunately we did not encounter any.

On the first day of the Symposium, a short opening ceremony was held. It was attended by Professor Sarkar and Professor Sathyamurthy who was acting director on behalf of Professor Dhande since the latter was leaving for New Delhi. Professor Bharadwaj gave the welcome address and, this was fol-

owed by addresses by Professor Sarkar, Professor Lee and Professor Sathyamurthy. All expressed the opinion that the Singapore-India Symposium has been a positive development and all parties should continue to work hard to maintain the momentum it has generated in fostering collaborative research. Professor Lee emphasised the fact that stemming from the previous event, a graduate student from the University of Pune was still in his laboratory as part of a 6-month attachment that began in September 2004.

The Symposium was officially closed on the second day. Representatives from both sides then attended a meeting for further discussion. The primary topic was on the future of SInCCCS. It was clear that our counterparts in India saw in NUS-Chemistry a strong and internationally-recognised department which they would like to continue building a strong relationship with. The idea of establishing memoranda of understanding to further advance collaboration ties was again suggested. Professor Lee invited his own colleagues and Indian chemists to identify collaborators so that student and faculty exchanges can be facilitated. He also announced that the 4th SInCCCS would be hosted by NUS-Chemistry and scheduled for either the end of 2005 or in 2006. Faculty members from IIT-Kharagpur, Chennai, Guwahati and the University of Hyderabad expressed the wish to host subsequent events after 2005/2006. This was heartening because it demonstrated the willingness of Indian colleagues to engage NUS-Chemistry in collaborative research and personnel exchanges.

The trip to IIT-Kanpur was a success; we were impressed with IIT-Kanpur’s chemistry research. It is probably the strongest in India, and we were continually reminded of this by its faculty members! Appropriately, there are high-quality faculty members in the Department of Chemistry, the calibre of whom would be welcomed by our own Department. The campus is spacious and green and has only a small number of students who are rigorously selected for admission. The biggest problem faced by the institute, we were told, is, attracting faculty members to settle in Kanpur since it is such an isolated city. For most of us who have never visited India, much less a top-rated research institution there, we were very impressed during our short visit.

We bade farewell to Assoc Prof Igor Novak (below) and Philip Barlow (see article in issue) in July 2005. Assoc Prof Igor has been with the Department since 1989 as a visiting teaching fellow, then Senior Lecturer in 1991 and as Associate Professor in 1998.

The Department welcomes Assoc Prof Stefan Kasapis, Dr Huang Dejian, Dr Martin James Lear, Dr Michael Adrian Lee, Assoc Prof Li Tianhu, Dr Xu Qing-Hua and Dr Xue Feng into our family.
“Science Celebrates” – 75th Anniversary, Faculty of Science  

Do you know that, officially, the Department of Chemistry started in 1929 with the opening of Raffles College for the teaching of Arts and Science? Hence in 2004 we celebrated our 75th anniversary together with the Faculty of Science community. The event was graced by the Deputy Prime Minister Dr Tony Tan.

The highlight of the celebration was a dinner held at Suntec City Ballroom, attended by more than a thousand guests, on the October 9, 2004. Here we feature some photographs taken during the dinner.

Guest and alumni viewing our posters and exhibits at the Chemistry Dinner at Suntec City Ballroom, where past Deans of Science cut the cake and offered their toast with NUS President

Congratulations, Prof. Kiang!

Emeritus Professor Kiang Ai Kim received the Distinguished Science Alumni Award 2004 during the Dinner. A feature on Prof. Kiang can be found in ChemConnections issue no. 3.
**Alumni Homecoming Day**

As part of Science 04, the Department of Chemistry has organized a series of events for our Alumni and members of the public on September 4, 2004.

A highlight on that day included a tour of the Chemical and Molecular Analysis Centre (CMAC).

Visitors were given a brief overview of the latest instruments by laboratory officers and faculty staff. A magic show was put up and graduate students demonstrated a series of interesting tricks to the children. A tea session was also specially arranged for our Alumni to meet their old friends and their contemporaries.

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**A Tribute to A/P Philip J. Barlow**

Assoc Prof Philip J. Barlow, the Director of the Food Science and Technology Programme (FST) within our Department is leaving and returning to UK. On June 26, 2005, we threw a grand farewell party at the Traders’ Hotel Singapore for A/P Barlow. The event was attended by nearly 180 people comprising of the Dean of Science, staff, corporate friends, alumni, undergraduates and postgraduates.

It was a heart warming night with speeches made by the Dean of Science, A/P Tan Eng Chye, the new FST Director, A/P Zhou Weibiao, representatives from the 1999 - 2004 batches of alumni and undergraduates and postgraduates. The video clip, performances and slide show put up by the students brought laughter and tears.

In his 6 years of pioneering leadership, the FST programme had grown from an intake of 30 students in 1999, to the current strength of nearly 200 comprising of alumni and students (For a brief introduction to FST program, read ChemConnections issues nos 2 & 3). A/P Barlow also established strong ties with industry and maintained high reputation of the Programme. Among the students, he was the ‘father’ and mentor of the FST family. His personality has helped create strong camaraderie among students, staff and alumni.

We cannot thank enough A/P Barlow for his significant contributions, leadership and dedication to the FST Programme. In order to have a long lasting tribute to him, the FST Alumni are in the process of setting up a P.J. Barlow Book Prize and we welcome all those who are related to FST and A/P Barlow himself to contribute. For details please contact Miss Lena Goh (lena@one.com.sg) or Miss Lee Chooi Lan (dbsleecl@nus.edu.sg).

‘Adios’ to A/P Barlow, till we meet again. We’ll remember him and wish him all the best in his future endeavours.
6th Singapore National Crystal Growing Challenge

Our Department, together with Singapore National Institute of Chemistry (SNIC), successfully organised the 6th Singapore National Crystal Growing Challenge for secondary school, junior college and polytechnic students on September 4, 2004. The students had an opportunity to show their creativity in the form of crystals and learn the science of growing crystals.

There were three categories in this year’s competition, Junior (for secondary school students), Senior (for Junior college and polytechnic students) and Open levels. For each category, there were first, second, third and two meritorious prizes carrying cash awards $400, 300, 200 and 50, respectively, in addition to trophies and medals for those responsible for growing the top three crystals.

This round, there were 168 entries from 68 educational institutions. Prof. Lee Hian Kee gave the welcome address followed by a special address by Prof. Andy Hor Tzi Sum, President of the Singapore National Institute of Chemistry. Assoc. Prof. Lam Kong Peng, Director of the Biomedical Research Council of A*STAR was the guest-of-honour of the prize presentation ceremony. This year’s competition was sponsored by Bruker Singapore Pte. Ltd., the Lee Foundation of Singapore and the Singapore National Academy of Sciences.

3rd HSA-NUS Annual Scientific Seminar

On May 11, 2005, the 3rd HSA-NUS Annual Scientific Seminar was held at the auditorium of HSA at Outram Road. Dr. Lu Yixin, A/P Leslie Harrison and A/P Jeffrey Obbard were the organizers on the NUS side. This seminar attracted over 100 participants, 14 talks were delivered and 11 posters were presented. The contributed papers covered a wide range of research areas, from Toxicology and Forensic Science, Environmental Science to Food and Drugs. The keynote speakers included Professor Sam Kacew, who is the Editor-in-Chief of the Journal of Toxicology and Environmental Health; Professor Ong Choon Nam, Director of Centre for Environmental and Occupational Health Research, NUS and Dr. Ngiam Tong Tau, CEO of Agri-Food and Veterinary Authority.

One new feature of this year’s seminar was that presentations would be considered for publication in the Journal of Toxicology and Environmental Health after peer review.

Professor Lee Hian Kee and Dr. Tan Chor Hiang, CEO of HSA delivered the opening speeches. Professor Lee emphasized the importance of research collaborations between NUS and HSA. This joint seminar served as an excellent platform for research scientists from both sides to present their original work and effectively promote direct interactions among researchers from different organizations which may lead to fruitful research collaboration in the future.

First Mini-Symposium on Medicinal Chemistry

On July 6, 2005, the Medicinal Chemistry program organized a one-day mini symposium entitled “First Singapore Mini-Symposium on Medicinal Chemistry: Advances in Synthesis and Screening”.

The opening speech was given by Prof. Hardy Chan, Vice-Dean of Research, Faculty of Science, followed by invited lectures. The four international speakers were:

- Prof. Hisakasu Mihara, Tokyo Institute of Technology
- Prof. Yoshinobu Baba, Nagoya University
- Prof. Injae Shin, Yonsei University
- Prof. Itaru Hamachi, Kyoto University

There were also two speakers from the Department - Dr Lam Yulin and Dr Martin J Lear.

Other than invited lectures, there were poster presentations from staff and students of the Medicinal Chemistry program. The response to the symposium was very encouraging, with attendance of students and staff from various departments, as well as representatives from companies.
Superconductivity is the property of a material to conduct electrical current with zero electrical resistance at temperatures below a certain critical temperature, $T_c$ (Figure 1). The first superconductor discovered was the elemental mercury Hg with a $T_c$ of 4.1 K by H.K. Onnes in 1911. Since then, superconductors have been found in other elements, intermetallics (metallic compounds), ceramics (inorganic non-metallic materials), fullerides (compounds of C$_{60}$) and even organic salts, with varying critical temperatures. The mechanism of superconductivity is complex and not completely elucidated. Basically, at sufficiently low temperatures, conduction electrons drop down to an energy level below their normal state. In this new state, the electrons can travel freely through the superconductor without colliding and losing energy.

Superconductors possess two unique (and useful) physical properties not found in other classes of materials. Firstly, the lack of electrical resistance, which enables a large electrical current to be carried without resistive heating compared to conventional copper wiring. Thus, a power grid utilizing superconducting wires will have negligible transmission losses. Thus, superconductors have enabled the development of equipment that requires a large magnetic field to be generated, such as Nuclear Magnetic Resonant (NMR) and Magnetic Resonant Imaging (MRI) machines. Secondly, a superconductor totally excludes magnetic fields within itself. This is the Meissner effect and it can be harnessed for magnetic levitation as embodied in 'maglev' trains.

At present, the superconducting wires in NMR and MRI machines are produced from intermetallic A15 compounds such as niobium tin, Nb$_3$Sn. Their critical temperatures are below 20 K, thus expensive liquid helium (boiling point 4 K) must be used for cooling the material to its superconducting state. Another class of compounds with higher critical temperatures, the copper oxide ceramics (cuprates), was discovered in the 1980’s. Many cuprates have been discovered such as yttrium barium copper oxide, YBa$_2$Cu$_3$O$_{7-x}$ (YBCO, $T_c$= 90 K); bismuth strontium calcium copper oxide, Bi$_2$Sr$_2$CaCu$_2$O$_8$ (BSCCO, $T_c$ = 110 K) and the current record holder of $T_c$, thallium-doped mercury barium calcium copper oxide, Hg$_{0.8}$Tl$_{0.2}$Ba$_2$Ca$_2$Cu$_3$O$_{8+y}$ ($T_c$ =138 K). Since their critical temperatures are mostly above the boiling point of liquid nitrogen (77 K), the cuprates are also known as high $T_c$ superconductors, and only requires inexpensive liquid nitrogen as a coolant. The relative cost of liquid nitrogen to helium may be compared to beer and whisky. Unfortunately, one of the problems limiting the widespread use of cuprate superconductors is the inherent brittleness of ceramics (think of a ceramic mug!), which makes them very difficult to be shaped into wires, compared to the ductile intermetallics. However, materials engineers have gradually surmounted the technical problems regarding wire fabrication. As a result, practical applications utilizing superconducting ceramic wires are now closer to reality.

My doctoral work at the Princeton University was on the solid-state chemistry of ruthenium and cobalt oxides, advised by Prof Robert J. Cava. One of my projects was to synthesize and study the crystal structure and physical properties of a newly reported ceramic oxide superconductor, so-

Superconductivity is a unique physical phenomenon with important ramifications, both for its theoretical understanding and practical, everyday applications. I am glad to have contributed to this field in my research.

Maw Lin received his B.Sc. (Hons) and M.Sc. degree in Chemistry from NUS in 1999 and 2000 respectively. He has just completed his doctoral studies in Chemistry and Materials Science at Princeton University, USA and is currently a postdoctoral fellow at the University of Toronto, Canada. His research interests are the synthesis and physical properties of solid-state inorganic materials. In December 2004, he married Ms Goh Bee Lian, who is also our alumnus. The couple send their best regards to their fellow classmates and NUS lecturers. They can be contacted at beeliangoh@yahoo.com.

Alumnus News

Superconductivity and my Ph.D. work

- by Foo Maw Lin
Our Department will be co-hosting the Singapore International Chemical Conference 4 (SICC-4) on December 8-10, 2005. It is a biennial conference dedicated to promoting advances in chemistry. This conference would be the fourth in this series and aims to reflect on the significant scientific developments in molecular synthesis and catalysis, to discuss new ideas and trends as we move into the twenty-first century, and to raise the profile of chemical sciences in Singapore. Within SICC-4 conference, a Chemistry Education Symposium will also be held.

The previous conferences SICC-3 (on physical and analytical sciences and green chemistry, http://www.sicc3.science.nus.edu.sg/) and SICC-2 (on chemical design and synthesis, http://www.sicc2.science.nus.edu.sg/), were held in Singapore in December 2003 and December 2001, respectively. Both were highly successful conferences with more than 500 participants.

We look forward to welcoming you in December 2005 as we meet, together with leaders from around the world in these increasingly complex and exciting fields of molecular synthesis and catalysis. For information, please contact the SICC-4 Secretariat at email: info@sicc4.com.sg

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Microscale Chemistry Workshop by Christer Gruvberg

Treatment of School Laboratories of the Future?

Can you imagine yourself running chemistry experiments using only tiny bits of chemicals all contained in several mini-plastic pipette bulbs that are stored inside a cassette box? The use of microscale chemistry experiments is not a new idea in chemistry teaching. However, with the increasing popularity and importance in green chemistry and environmental education, the value of an inexpensive yet environmentally-friendly microscale chemistry laboratory is rising fast. Recognizing such a trend, separately in November 2004 and May 2005, two workshops were conducted in NUS to equip teachers and laboratory technicians from local secondary schools with the skills and experience in setting up microscale chemistry experiments in school laboratories.

The workshop in November 2004 was organized jointly by NUS Chemistry and SNIC. Christer Gruvberg, a renowned educator in Sweden who travels often to different parts of the world to conduct workshops, was invited to Singapore again following his initial stint in 2002. His flashy chemical demonstrations and state-of-the-art microscale apparatuses succeeded once again to amaze the workshop participants. However, one of the biggest challenges in implementing microscale chemistry experiments in Singapore had been the availability of the microscale apparatuses. Mrs. Gan Hooi Leng, who was a participant of the November 2004 workshop and is the Head of the Science Department at Kuo Chuan Presbyterian Secondary School, managed to introduce microscale chemistry experiments to her school cluster (Cluster S7) after months of hard work that was put in to look for raw materials and to assemble the microscale apparatuses locally instead of having them shipped in from overseas. The workshop in Cluster S7 took place in May this year, and it was very well received. The next steps in promoting microscale chemistry experiments may include reaching out to more schools in Singapore and to develop a wider variety of such experiments to cover more chemistry topics.

by Dr. Alan K. Szeto