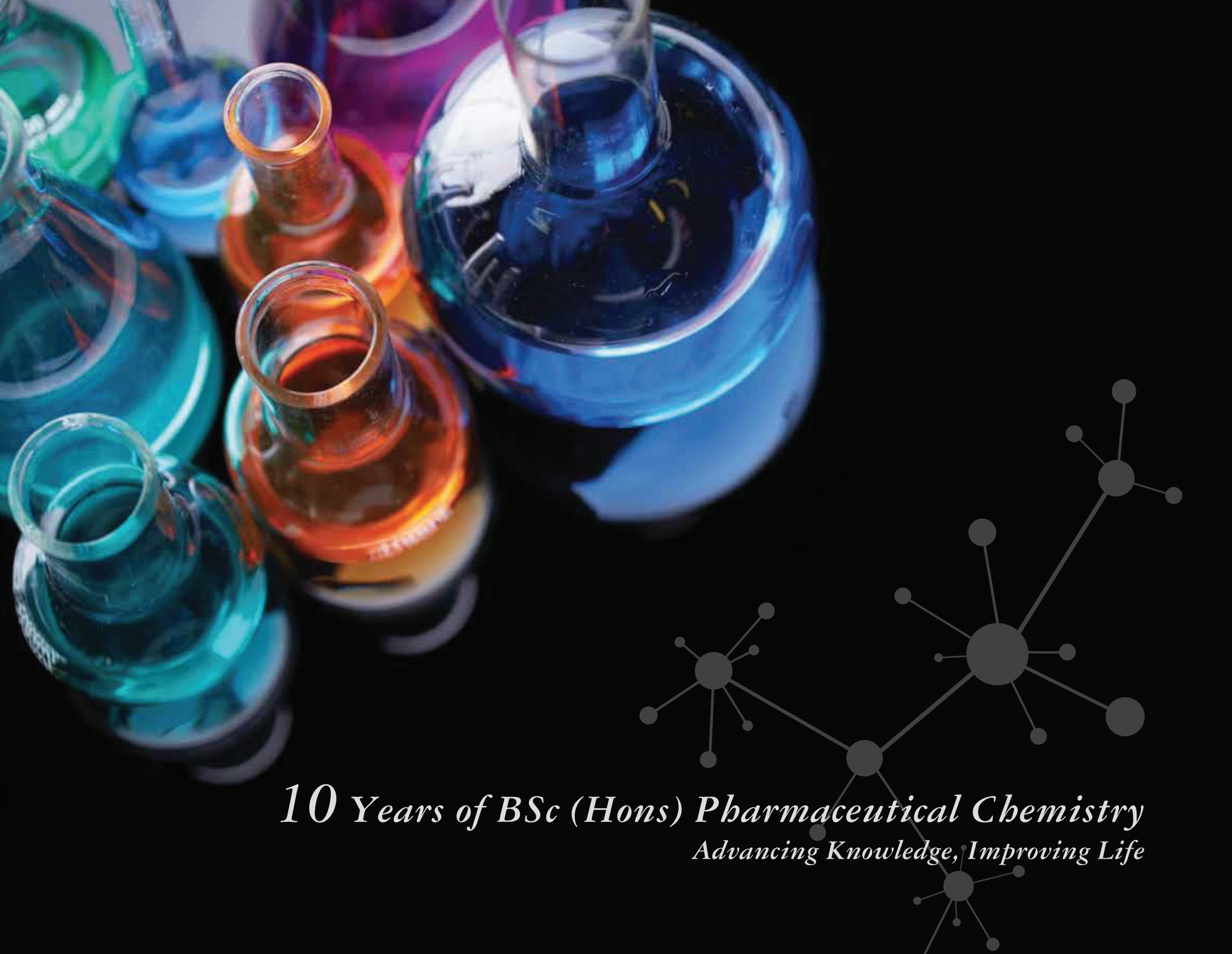

10 Years of BSc (Hons) Pharmaceutical Chemistry

Advancing Knowledge, Improving Life

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Contents

04 Foreword and Messages

14 Pharmaceutical Chemistry in IMU

22 Pharmaceutical Chemists - Making the World a Better Place

44 Achievements

52 Departmental Activities

58 Staff

68 Students

78 Alumni Speak

84 Congratulatory Messages

88 Moving Forward


CHAPTER
01

Foreword and Messages

From the Dean of the School of Pharmacy

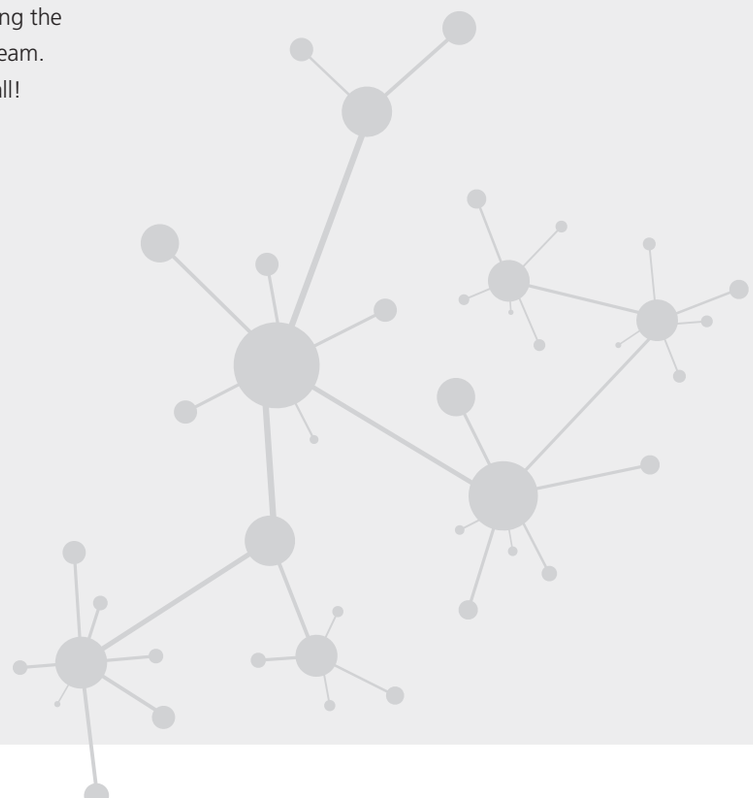
A/Prof Dr **Mohd Zulkefeli Mat Jusoh**

2018 is a major milestone for the Department of Pharmaceutical Chemistry, as we commemorate an extraordinary 10th Anniversary for the Bachelor of Science (Honours) programme in Pharmaceutical Chemistry.

We are immensely proud of the 159 Pharmaceutical Chemistry graduates that are making their mark in the pharmaceutical and chemical industry sectors as well as in research and academia. We are also very excited that this celebration coincides with the International Postgraduate Conference of Pharmaceutical Sciences (IPOPS) that we are organising and hosting.

In the span of 10 years the Pharmaceutical Chemistry programme has come a long way. It was only in 2008 that the University welcomed its first cohort of 20 students into this pioneering programme, the first in Malaysia to provide both comprehensive and focused undergraduate training in Pharmaceutical Chemistry. Reflecting its high standards, the Pharmaceutical Chemistry degree programme has, since 2014, received accreditation from the Royal Society of Chemistry. A further testament of quality is the eligibility of our graduates to undertake the graduate entry Master of Pharmacy programmes at the University of Sydney and Curtin University, with credit exemptions.

This 10th Anniversary thus offers a wonderful opportunity to reflect upon the history and development of the Programme, and to look at the remarkable journeys and great passion of our students and staff, past and present. As we celebrate 10 years of success, we take pride in the Programme's achievements and we are inspired about its future. We will continue in our mission of preparing versatile, adaptive graduates who can help improve lives and help solve the problems of our complex world. As Dean, I look forward to growing the Programme with our Pharmaceutical Chemistry team. Once again, congratulations and best wishes to all!



From the Deputy Vice-Chancellor, Academic

Prof **Peter Pook Chuen Keat**

Back in 2005, I was deeply honoured to lead the Pharmaceutical Chemistry department as Dean of the then School of Pharmacy and Health Sciences. Ten years ago, under the leadership of A/Prof Dr Er Hui Meng, the Pharmaceutical Chemistry programme was born.

From these small beginnings, the programme has grown with time into what it is today, with two intakes in a year and a Master in Analytical and Pharmaceutical Chemistry programme which started in 2012. The story of the Pharmaceutical Chemistry programme features a group of key originators led by A/Prof Dr Er Hui Meng, A/Prof Dr Kang Yew Beng, A/Prof Dr Mak Kok Fee, Prof Mallikarjuna Rao Pichika, A/Prof Dr Ooi Ing Hong, Dr Shubhadra and Kenny Ong. We also applaud the invaluable input and support from staff of the Multidisciplinary Laboratories, Academic Services, the e-Learning Department, Academic Programme Development, Facilities and Management, Marketing, Student Admissions and Services, and Information and Communication Technology. These are all people who have worked tirelessly behind the scenes to develop and support this Programme.

As a former Dean, I have been privileged to witness the phenomenal growth of the Programme and its expanding role in raising the profile of the Pharmaceutical Chemistry department.

The programme has established strong partnerships with trans-national pharma companies such as Novartis and Oncogen, working together to create an industry-driven programme that is highly relevant to the pharma sector.

Yes, it has been 10 years but it still feels like day one. As the pace of innovation has increased, the stakes are now higher, with many other institutions offering programmes with similar content. The Pharmaceutical Chemistry team strives to share, adapt, and become the most enthusiastic and impactful professionals that they can be, in both research and academic programme development. The team has successfully secured research funding from Toray, the Royal Society of Chemistry, the Malaysian Government E-Science fund, and the Fundamental Research Grant Scheme. Thank you for the passion and persistence that you have shown daily in these last 10 years.

Let's keep going and growing for many more multiples of 10 years! Like many other colleagues and ex-colleagues, I'm happy to have witnessed the robust growth of Pharmaceutical Chemistry programme over the years, be it in academic and research developments or support for students, and its profound impact on the community with staff's active involvement in the professional bodies (IKM, ACS and RSC) by making this program visible to all. I look forward to your support and participation in our celebratory events. I would also like to take this opportunity to thank all the former colleagues who have paused here for a bit before continuing on their journeys, and for the current academic staff and corporate staff who have stuck with the team for all their contributions and hard work to sustain this programme over the years.

As Malaysia continues to envision and explore more viable means of providing pharmaceutical chemistry and related programme, IMU Pharmaceutical Chemistry department marches on with unswerving determination. It is ready to fulfil its mission of playing a greater role in excellence-orientated and quality-assured higher education. Each of us here today has our individual experiences in the Pharmaceutical Chemistry department at International Medical University. Combined, we form a tapestry of success stories that is beautiful, inspirational and challenging. Good reputations spread and we inspire excellence and make a world of difference to the pharmaceutical industry. Once again, congratulations to the team and I wish all staff and graduates every success in the future.

From the Vice-Chancellor

Prof **Abdul Aziz Baba**

The 10th anniversary of Pharmaceutical Chemistry programme marks another milestone achievement for IMU as an innovative global centre of excellence for undergraduate programmes and research in medicine, pharmacy and other health sciences.

International Medical University (IMU) established the Bachelor of Science with Honours (BSc (Hons)) Pharmaceutical Chemistry in 2008 to cater for the manpower needs of the rapidly expanding pharmaceutical industries sector. Already well known as a centre of high quality undergraduate medical and dental programmes, IMU embarked on introducing another high quality undergraduate programme in the healthcare and related fields. Introducing this Pharmaceutical Chemistry programme and later the Master in Analytical and Pharmaceutical Chemistry was part of an overall mission of IMU to link upstream with the downstream industries, or expand from healthcare education to drug discovery and pharmaceutical manufacturing education.

According to the Malaysian Organisation of Pharmaceutical Industries (MOPI), the total market size for prescription and over the counter (OTC) medicine was estimated at RM4.5 billion in 2009 while the traditional medicine and health supplements market was estimated at RM3 billion. Market growth in Malaysia has been fairly consistent at between 8% - 10% annually for the past several years. On the other hand, worldwide revenue of the pharmaceutical market rose from US$830.6 billion in 2009 to US$1105.2 billion (about RM4,508 billion) in 2016. As such, there is a growing demand locally and in other parts of the world for well-trained pharmaceutical chemistry graduates and researchers who can contribute to the continual growth of the pharmaceutical industry.

In IMU, we develop students to reach their true potential in becoming competent, ethical, caring and inquiring citizens. IMU is also committed to academic freedom and the principles of equal opportunity in the pursuit and application of knowledge, the highest standards of intellectual, educational and research productivity; and the establishment of a learning organisation that respects the individuals. In the ten years of its existence, the Pharmaceutical Chemistry programme had undergone various phases of development to enhance its international reputation and recognition, in line with our university vision and missions. Here, I would like to congratulate the staff of the Pharmaceutical Chemistry department and other supporting staff for the tremendous effort put in to achieve this milestone.

From the Class Representative of the First Cohort

Chris Foong Kok Wah (PC1/08), Seafreight Procurement and Allocation Executive, Kuehne + Nagel

> We are proud to be part of the University's community.
>
> **Chris Foong Kok Wah**

Firstly, I would like to thank the School of Pharmacy for inviting me to write a message on behalf of all my colleagues in cohort 'PC1/08' – We were the first to undertake the BSc (Hons) in Pharmaceutical Chemistry. It is now ten years from the first day we joined this programme of study. I'm glad that graduates of PC1/08 are doing well in their respective fields of endevour. We are now all over Malaysia, in Singapore and Australia.

Undertaking the programme was not an easy journey, and we faced challenges throughout our study life. Nonetheless, our programme coordinator and lecturers tried their utmost to smoothen our learning process, using effective methods. Hence, we would like to thank them for their hard work.

While undertaking the course our strengths and weaknesses were identified, and we were given the opportunity to acquire problem solving skills in a good manner. In addition, self-confidence and a sense of ownership were developed throughout this course.

These skills were useful as a foundation before we stepped into the real world and built our careers.

Lastly, we are proud to be part of the University's community.

We wish our juniors all the success in their studies, as you have the support from a strong team of faculty. Happy 10th anniversary to Pharmaceutical Chemistry Programme. Thank you IMU.


CHAPTER
02

Pharmaceutical Chemistry in IMU

A History of the Programme

A/Prof Dr **Er Hui Meng**, Founding Member of the Pharmaceutical Chemistry Programme and Associate Dean, Teaching and Learning.

> "I take this opportunity to congratulate the School of Pharmacy and the Department of Pharmaceutical Chemistry on this milestone. Happy 10th Anniversary to the BSc (Hons) Pharmaceutical Chemistry Programme!"
>
> A/Prof Dr **Er Hui Meng**

In the early 2000s, the Malaysian pharmaceutical market and manufacturing experienced rapid growth, driven in part by the patent expiration of many global blockbuster drugs. Despite governmental efforts to contain rapidly increasing healthcare costs, the market still relied heavily on imported medicines. Recognising its potential, the Malaysian government identified pharmaceutical industry as a strategic industry for development and growth. To address the manpower needs of the pharmaceutical industry, the BSc (Hons) Pharmaceutical Chemistry programme was developed. After nearly three years of planning and preparation, the programme was launched in July 2008.

The programme was the first in Malaysia to provide complete and specialised training in pharmaceutical chemistry, as opposed to wider training in pharmaceutical sciences. Benchmarked to international standards and criteria, the programme has been designed and developed with inputs from key academics and industrial leaders, to produce graduates with

technological knowledge and skills able to contribute to the rapidly growing pharmaceutical industry. Students are trained in the application of modern information and scientific technologies in drug development, safety and efficacy studies. The programme offers significant hands-on practical training with the opportunity to conduct research in the final year. Industrial workplace learning is an essential component, that enables students to gain first-hand industrial experience. Other than the pharmaceutical industry, the graduates also find employment opportunities in the oleochemical, palm oil, food, biotechnology, cosmetics and toiletries sectors. Besides, they can work as clinical trial coordinators or continue on to postgraduate training in related disciplines.

The inaugural intake of the programme commenced on 14 July 2008. The programme has been privileged to have a team of dedicated faculty with vast academic and relevant industrial experience, who implement the curriculum based on contemporary educational principles and practices. This has been made possible with frequent faculty development activities supported by the University. In addition, the faculty continually engage with pharmaceutical industry to ensure that the curriculum is aligned with the trends and practice in the pharmaceutical industry worldwide. The number of students in each cohort has continued to grow since its launch. Meanwhile, institutional efforts ensure international recognition of the programme. In 2011, IMU and the University of Sydney, signed a credit recognition agreement for eligible graduates of the BSc (Hons) Pharmaceutical Chemistry programme to enrol in the University of Sydney Master of Pharmacy (MPharm) programme with award of credit points of advanced standing. Similarly, credit recognition arrangement was established with the Curtin University of Technology, Australia, for its MPharm programme in 2013. In the same year, the IMU BSc(Hons) Pharmaceutical Chemistry programme was granted international accreditation by the Royal Society of Chemistry of the United Kingdom.

Being a member of the programme design team and its first programme coordinator, I am extremely proud to witness the growth of the programme since its inception. I am honoured to be part of the Pharmaceutical Chemistry team which has a strong culture of team work and a common vision to produce graduates who are work ready for the pharmaceutical industry. Seven cohorts of students have graduated thus far, and some graduates have continued into postgraduate studies in internationally renowned universities locally and abroad. Most importantly, graduates are progressing well in the careers of their choice, and many of them have attained senior positions in the pharmaceutical and other industries. Many of these alumni have attributed their success to the training they received in IMU. Their career accomplishment is definitely the best reward for the teaching faculty.

Is the Future of Chemistry like 'Heisenberg'?

A/Prof Dr **Kang Yew Beng,** Founding Member of the Pharmaceutical Chemistry Programme and Associate Dean, Teaching and Learning.

"

$$y = \frac{\frac{10}{a^{p^2}} \pm \frac{a^{n^2}}{a^{p^2}}}{H}$$

$$Hy = \frac{\frac{10}{a^{p^2}} \pm \frac{a^{n^2}}{a^{p^2}}}{1}$$

$$Hya^{p^2} = 10 \pm a^{n^2}$$

$$Ha^{pp}y = 10 \pm a^{nn}$$

"

A/Prof Dr **Kang Yew Beng**

The Beginning

Chemistry is a mature science. Its philosophical roots may be traced back to the early 17th century tradition of philosophia naturalis which was imbued with the German tradition of Naturphilosophie and inspired by the great philosophers Goethe, Hegel and Schelling.

Its scientific roots were in alchemy, a proto-science that attempted to explain the nature of transformation, especially of metals and metallurgy. The chief pursuit of alchemy was transmutation, the supposed ability to transform base metals into gold. Modern chemistry came to life in the 16th and 17th centuries with the contributions of Robert Boyle, who introduced modern experimental scientific method, and who is credited with the gas law that bears his name; Joseph Priestly, who discovered ten new 'airs', one being oxygen; John Dalton, and his atomic theory and a law to describe the relationship between the components of a mixtures of gasses and their contributions of partial pressures; and not least, Antoine de Lavoisier, the 'father of modern chemistry' credited with the Law of Conservation of Mass.

The Past

Chemistry made great progress and experienced mass market appeal in the growth period known as the Industrial Revolution. Although history remembers this period in terms of mechanisation, the steam engine, the growth of the textile industry and in agriculture, the role of chemistry was paramount. For example, organic fertilisers were first used in agriculture. Chemistry brought inorganic fertilisers, and later, pesticides and gibberellins, or plant growth hormones. The use of coke instead of charcoal for smelting (Abraham Darby, 1709), blast furnaces (ca. 1760), and steel production using the Bessemer furnace (ca. 1850) necessitated insights into chemical reactions, metallurgy and thermodynamics. The textile industry required both natural dyes (indigo, alizarin, Tyrian purple), and mordants as fixers to set the dyes to textile fibres. The introduction of the synthetic dye mauve by WH Perkins freed textile production from the bottleneck of having to rely on dyes from natural, variable, sources.

The years following the start of the 20th century to the 1970s were a golden age for chemistry. Many of the chemical 'concoctions' we use daily at home are examples of how chemistry and its products have become part of our daily lives. These products include medicines, clothing, and electronics. Chemistry has impacted the kitchen to the living room. The rise and rise of chemistry during this period justifiably coincided with a period of curiosity-driven and application-based discoveries. This period brought us spectroscopy and laser spectroscopy, x-rays, quantum chemistry, catalysis, complex organic chemistry, organometallic chemistry, coordination chemistry, medicinal chemistry, Buckminsterfullerenes (Bucky balls), Langmuir films, and lately, graphene. During this highly productive or perhaps commercially-driven period, chemistry has always blended the practical and the conceptual.

The Present

Chemistry has since shifted its focus into new fields such as biomolecules, materials science and computational chemistry to name but a few. Chemistry for all its myriad products has evolved away from its so-called core disciplines towards iterative improvement rather than fundamental discovery. Nevertheless, one can easily argue that five discoveries have shaped the modern world:

- Penicillin and drug discovery processes
- The Haber-Bosch process and synthetic fertilisers
- Polyethylene and synthetic polymers
- Progesterone, corticosteroid-based hormones and total synthetic chemistry
- The Langmuir film and surface properties

Many other discoveries demand recognition, but space does not permit their inclusion here. Some chemists, myself included, feel that we reached an incredible era of chemistry driven industrial growth which benefited mankind with many products and processes.

However, there are many problems, for example pollution and climate change, that may be blamed on chemistry. Although its golden age has seemingly ended, chemistry can still provide leadership, if not solutions. These solutions do not lie in the manipulation of atoms and molecules, but in the control of complex systems. Chemistry must expand its definition from only molecules to everything that involves molecules. Industry and academia need to abandon the traditional distinction between science and engineering, biology and mathematics in order to better understand the nature of complex systems. This in turn better prepares students to tackle emergent problems that are not yet problems at the time the students are being trained.

The Future?

This brings us to the future and the title of this perspective – The future is 'Heisenberg' or implicitly uncertain. Heisenberg's Uncertainty Principle famously stated for two observations that do not commute, if the first observation is completely known, then the second is completely unknown. An example is that if the momentum of an electron around an atom is to be defined exactly, then the exact position of that electron cannot be known, at the same time.

The future of chemistry is rather like the Uncertainty Principle. There is a Heisenbergian relationship between problems and possible solutions. Rather than approach it as if the problem is known, and the solution unknown, this author feels that the reality is that no one really completely understands either the problems or their solutions. Does this mean that the need for chemistry is now over? Far from it. Even a cursory examination of the problems facing society will show that chemistry is still very much needed.

Universities must lead the change to teach the next generation the ability to solve problems. There are opportunities for chemistry to deploy its unique skills and abilities, such as in molecular synthesis, complex systems, environment, energy, water and energy sustainability.

Universities need to produce the next generation of chemists who are entrepreneurial, using their chemistry knowledge and skills to suggest and test solutions to these complex problems. Seneca wrote "Non scholae, sed vitae discimus": 'We learn not for school but for life.' This means that chemistry education must be re-imagined and re-invented and must move towards generalisation instead of specialisation. Textbooks and lectures must be replaced by online and on-demand access to up to date information. We must stop dumbing down technically challenging and complex topics such as solvation, thermodynamics, electrochemistry, advanced mathematics, flow dynamics, systems and complexity. One day, perhaps, a chemistry student will be tested with questions such as those proposed below, to uncover creativity, entrepreneurial ability and not just tacit recall.

Probably Pharmaceutical Chemistry examination paper in 202*

Recreate the modern world of chemicals with only CO_2 , H_2 , heat and e^-. (60 marks)

Identify how clays can be used to generate organic molecules from simple hydrocarbons. (10 marks)

'Organic building blocks of life arose from comets.' Propose reaction schemes that support this view. (10 marks)

Suggest how resonance stabilisation from Hückels rule may drive the formation of resonance stabilised aromatic and heteroaromatics. (20 marks)

Construction of assessments like the above might finally shift the emphasis from recall of facts (which will change under the scrutiny of the scientific method) to evaluation and synthesis which are highest domains of the Bloom's taxonomy. I will only dare to dream.


CHAPTER
03

Pharmaceutical Chemists - Making the World a Better Place

Pharmaceutical Chemistry as a Profession

A/Prof Dr **Ng Chew Hee** and A/Prof Dr **Ooi Ing Hong,** Department of Pharmaceutical Chemistry.

"Congratulations to our Pharmaceutical Chemistry Programme 10th Anniversary:

IMU pioneering Pharmaceutical Chemistry education – manpower for the growth of pharmaceutical industry in Malaysia."

A/Prof Dr **Ng Chew Hee**

A profession is an occupation that needs specialised education and training to develop specific skills. A profession is also a disciplined group of individuals who adhere to ethical standards; who profess special knowledge and skills, and are recognised by society as such. Learning, specialised knowledge and unique skills derive from systematic, often long, study and training, and from ongoing research.

A profession is committed to using its knowledge in the service of society. Professions are also characterised by ethical standards and codes of conduct that are internally enforced. Such codes require behaviour and practice beyond that required by personal and individual moral obligations. Codes define and demand high standards of behaviour with respect to services provided, and in dealing with professional colleagues. Such codes are enforced by the profession itself and are acknowledged and accepted by the community at large. In Malaysia, all chemists, including pharmaceutical chemists, can gain recognition as professionals if they join the Malaysian Institute of Chemistry (Institut Kimia Malaysia), a statutory professional organisation which was incorporated under the Chemists Act 1975 in November 1977, and is regulated by the Ministry of Science, Technology and Innovation.

Pharmaceutical Industry in Malaysia

The pharmaceutical sector is among the different kinds of industries where chemists find employment. The Malaysian Organisation of Pharmaceutical Industries (MOPI), incorporated in 1981, has a membership of 44 pharmaceutical companies.

The Malaysian government has long recognised the need for a vibrant pharmaceutical sector, particularly pharmaceutical manufacturing and production, to reduce economic reliance on imported pharmaceuticals, and to grow exports. Product manufacture includes prescription and over the counter medicines, herbal and traditional medicines, health supplements and cosmeceuticals.

The key properties of marketed medicinal products, namely quality, safety and efficacy are regulated by law in most countries worldwide. Indeed, pharmaceutical production and marketing are among the most highly regulated sectors worldwide, driven in part by the need to protect consumers.

The relevant Malaysian legislation is the Control of Drugs and Cosmetics Regulations 1984, which specifies that all products in pharmaceutical dosage must be registered with the Drug Control Authority that carries out its duties through the National Pharmaceutical Regulatory Agency.

The market for prescription and non-prescription medicines has grown rapidly. In 2009, the total market size was estimated at RM4.5 billion; the traditional medicine and health supplements market was an estimated RM3 billion. Of the 250 DCA licensed manufacturers in 2011, 74 companies manufactured prescription and non-prescription medicines, and another 176 produce traditional medicines. There were 207 licensed manufacturers of cosmetics and/or toiletries. These companies export to countries in South East Asia, Africa and the Middle East. Exports have grown steadily by between 10% to 12% annually. There has been strong emphasis on research to enlarge and enhance product portfolios.

Pharmaceutical Chemistry education, and employment prospects

Pharmaceutical chemistry is a multi-disciplinary science that deals with drug design and synthesis development, product formulation and testing, as well as the delivery of drugs within the human body. At IMU, students undertaking degree studies in Pharmaceutical Chemistry (PC) undertake both modules unique to the PC programme, and also some shared modules with the Pharmacy program. The PC program was the first in Malaysia to provide comprehensive and specialised training in pharmaceutical chemistry. The curriculum begins with foundational sciences in the early phase, and in the later phase, extends to the applied knowledge and skills associated with drug development. The programme is recognised by both Institut Kimia Malaysia and the Royal Society of Chemistry of the United Kingdom, and as such, graduates are eligible for membership with IKM and RSC. Naturally, graduates have the option to undertake graduate study in pharmacy and chemistry, such as the Master of Pharmacy programmes of the University of Sydney and Curtin University in Australia. In fact, the IMU PC programme is unique in that graduates can find employment in the two large sectors, chemical and pharmaceutical, summarised in the Table below.

AREAS & SCOPE OF WORK OF PHARMACEUTICAL CHEMISTS	
Pharmaceutical industry	Research & development, manufacturing, quality control, quality assurance, medical information, regulatory affairs, compliance, clinical trials, sales & marketing
Biotechnology	Manufacturing, quality control, quality assurance, sales & marketing
Cosmetics & toiletries	Research & development, manufacturing, quality control, quality assurance
Nutraceuticals	Research & development, manufacturing, quality control, quality assurance
Academia	Research project assistants, instructors for undergraduate classes, science officers, laboratory officers
Governmental agencies	Quality control, quality assurance, enforcement. Working in chemistry departments in different states of Malaysia, SIRIM, and other government agencies.

Pharmaceutical chemistry graduates may also find employment in petrochemical, oil and gas, wood industry, medical devices, food & sustainable resources, non-metal mineral industry, basic metal and fabricated metal products, textiles and textile products, electrical and electronics, palm oil and palm oil products, wood & timber processing, rubber glove industry, plastic industry, beverages and tobacco products, and others. Among these sectors, petroleum, rubber and plastic are major contributors to the Malaysian economy with a gross output of RM307 billion (30.4%) in 2014. The industry comprises an important part of the fast growing Malaysian economy, and total contribution to Malaysia's GDP in 2010 was 41.6 percent. In Peninsular Malaysia, rubber, oil palm processing and manufacturing, light manufacturing, pharmaceuticals, medical technology, electronics, tin mining and smelting, logging, and timber processing are some of the key industries. Whereas in the Eastern Malaysian states of Sabah and Sarawak, the economy is more focused on logging, petroleum producing and refining and agriculture processing. Data for March 2017 from the Statistics Department showed that Malaysia's manufacturing sector continues to grow, with sales jumping 13.6% to RM65.9 billion compared to the same month a year ago. Therefore, pharmaceutical chemists have access to many job opportunities. Besides working in the private sector, graduates can work in various government institutions, like Department of Chemistry Malaysia, Pharmaceutical Services Division (Ministry of Health), and Pharmacy Enforcement Division (Ministry of Health).

From the above survey, it can be seen that the pharmaceutical chemists have a wide range of employment options, including those in the fast developing pharmaceutical industries, in both Malaysia and other parts of the world. Their job scopes include navigating through various regulations. In addition, they subscribe to a code of ethics by belonging to a professional body like IKM. Pharmaceutical Chemistry is an emerging profession. By maintaining a high ethical standard, pharmaceutical chemists make pharmaceutical chemistry a respected profession.

Research in Pharmaceutical Chemistry: Towards Development of Medicines

Mak Kit-Kay (PC1/12), MSc student, School of Postgraduate Studies and Research.
Prof **Mallikarjuna Rao Pichika**, Associate Dean, Research and Consultancy, School of Pharmacy.

"I am so pleased to witness the celebration of BSc (Hons) Pharmaceutical Chemistry's first decade of accomplishments here in IMU. Congratulations and Happy 10th Anniversary!!"

Mak Kit-Kay

Pharmaceutical Chemistry, sometimes also referred to as Medicinal Chemistry, is the science dealing with the design, discovery and development of medicines. It is an interdisciplinary science that requires diverse knowledge as shown in Figure 1.

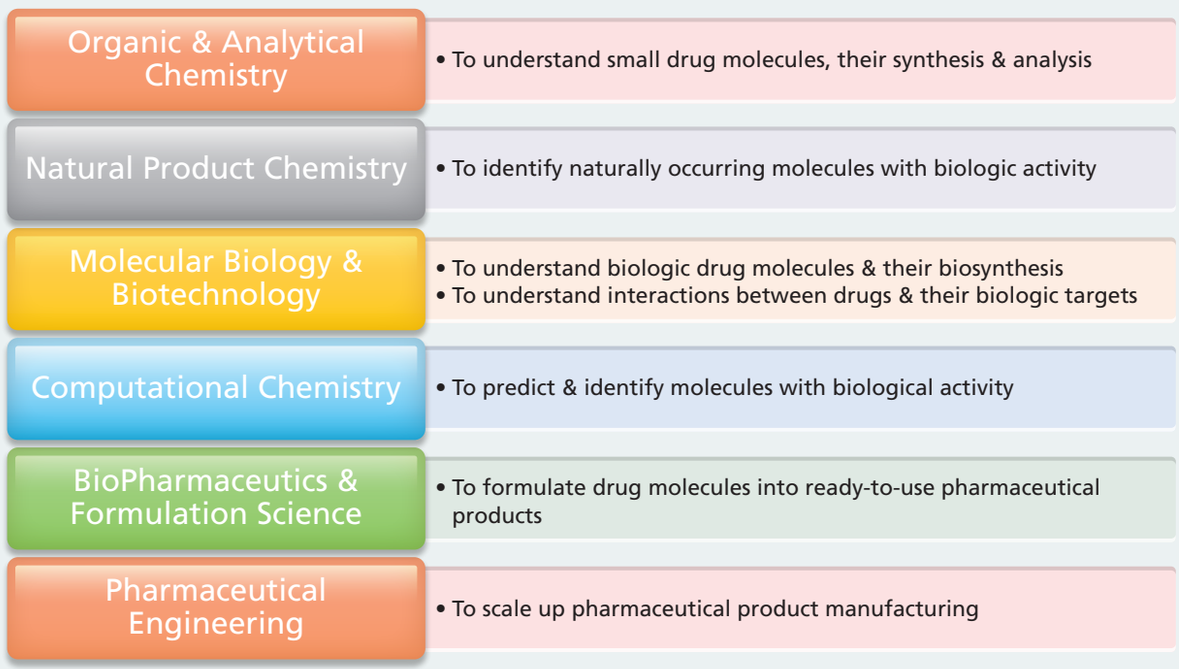


Figure 1: Core knowledge domains in which pharmaceutical chemists must be proficient to be successful in drug development.

The leading role of the pharmaceutical chemist in drug development is of using all the available tools and techniques to create molecules able to treat diseases. The feedback-driven discovery process starts from existing results obtained from various sources such as high-throughput compound & fragment screening, computational modelling or literature review. Feedback-driven discovery alternates between induction and deduction. This inductive-deductive cycle eventually leads to optimised hit and lead compounds. Automation of specific parts of the cycle reduces randomness and error, and improves the efficiency of drug discovery. De novo design methods require knowledge of organic chemistry for in silico compound synthesis and virtual screening models that function as surrogates for biochemical and biological tests of efficacy and toxicity. Ultimately, active learning algorithms allow the identification of new or novel compounds with promising activities against a given disease target.

The efficient pharmaceutical chemist?

The journey to have a successful career in anything you do is to be great at what you do. Figure 2 lists the strategies for success in drug discovery as a pharmaceutical chemist.

Figure 2: Strategies for success in drug discovery.

Drug discovery: Past, present and future of drug discovery

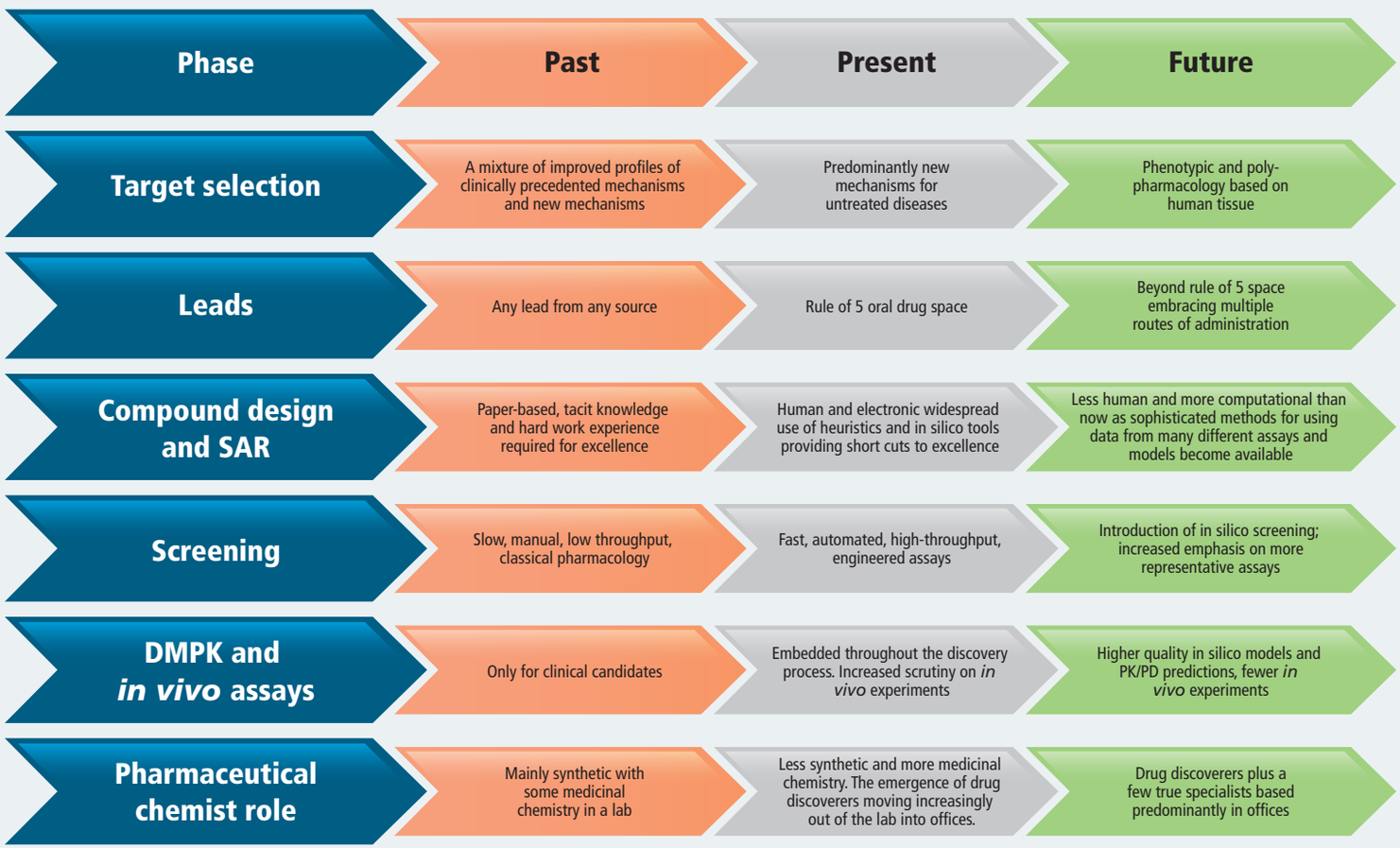


Figure 3: How pre-discovery processes and role of pharmaceutical chemists have evolved.

"Wishing BSc (Hons) Pharmaceutical Chemistry a very happy 10th year anniversary. It is an honour to be a part of the IMU family. I have always believed that chemistry is one of the many universal languages. That paired with IMU's holistic approach in education, students are prepared to not just transition smoothly to their work life, but they are equipped with the knowledge, mentality and tools required to stand out in a challenging and constantly changing work environment. In the borderless world of chemistry knowledge, it welcomes you with open arms to be part of an entity that shares a global vision in scientific discovery."

Prof **Mallikarjuna Rao Pichika**

What of the future for drug discovery?

Significant scientific, commercial and healthcare systems related factors point to the continuing introduction of many new drugs in the foreseeable future. The sciences supporting and enabling rational drug design continue to advance, with a corresponding increase in the number of scientists with experience in drug development (Figure 3). Advances in synthetic organic chemistry permit the synthesis of complex naturally occurring products with great efficacy that was earlier thought possible.

The global pharmaceutical market continues to grow, with changes in disease patterns, ageing populations, emerging markets, and growth in generics and biosimilar as some of the key factors. Historic, significant commercial successes and patent expiration continue to be strong stimuli for significant pharmaceutical investment in drug discovery. The global threat of increasing antibiotic resistance is another stimulus. At the same time, diagnostic technologies continue their rapid advance, with the potential to develop new treatments. Pan-national pharmaceutical companies are adopting risk-reduction techniques, permitting them to remain successful in drug development. Smaller pharmaceutical companies pick up neglected diseases as their priority, where big pharma competition is less.

Healthcare systems continue to recognise the value of preventive strategies so there will be an increase in demand for new supplement products. Governments encourage prepaid vaccine and drug development programmes with guaranteed buy back agreements by the pharmaceutical industries.

In 2011, in a crystal ball look into the nature of medicinal chemistry in 2020, Satyanarayanajois and Hill wrote that "with rapid advances in rational-design approaches in recent decades, the 'drug-discovery' process has become a 'drug-creation' process, at the center of which are medicinal chemists. They have become multidimensional puzzle solvers, bringing to bear a body of science that has vastly expanded over the past couple of decades, and will continue to rapidly grow and evolve." Their assertion seems more true than ever.

Professional Affiliations

Chemists in Malaysia have the opportunity to be affiliated with a number of professional organisations that promote the profession and advance chemistry. The most prominent of these professional bodies are Institut Kimia Malaysia (IKM), the Royal Society of Chemistry (RSC), and the American Chemical Society (ACS). Many School faculty are active members of these bodies and are enthusiastically involved in activities that significantly benefit society.

INSTITUT KIMIA MALAYSIA

ROYAL SOCIETY OF CHEMISTRY

ACS Chemistry for Life® MALAYSIA CHAPTER

The Malaysian Institute of Chemistry (IKM)

Advancing chemistry and professionalism in chemistry for knowledge generation, wealth creation and improving quality of life

A/Prof Dr **Ng Chew Hee** and A/Prof Dr **Ooi Ing Hong**, Department of Pharmaceutical Chemistry.

Established in 1967, IKM has become a full-fledged scientific and professional organisation, recognised locally and internationally. Over the last 50 years many significant achievements have been made. From its humble beginning in 1967, IKM was incorporated under Chemists Act 1975, which enables it to regulate the practice of chemistry in various fields. In addition to accepting chemistry graduates as members, IKM also provides training, including refresher courses; and conducts the annual Part I Examination to prepare under-qualified individuals for admission to membership. The IKM Professional Centre provides continuing professional development for all its qualified members. To date IKM membership includes 4,226 registered chemists, comprising practising chemists in the government, manufacturing and service sectors and academia; and researchers and scientists at research and development organisations, both in government and private sectors.

Internationally, IKM plays a vital role in the development of chemistry in Asia through its membership of the Federation of Asian Chemical Societies, and its participation in International Union of Pure and Applied Chemistry programmes and activities such as organising IUPAC conferences through the National Adhering Organisation of the IUPAC.

IKM is actively engaged in working towards the United Nations Sustainable Development Goals, by working with universities, research and development institutions and the Government, and by continuing to organise many scientific meetings, conferences and exchanges. Through a number of programmes including Kuiz Kimia Kebangsaan Malaysia (K3M), Karnival Kimia Malaysia (K2M), and other outreach programmes, IKM promotes interest in chemistry to secondary school students.

Furthermore, according to IKM president Datuk Dr Soon Ting Kueh, IKM intends to set up an IKM Young Chemists Network (IYCN) for young chemists to interact and exchange ideas for a better future, and also encourages the formation of Postgraduate Clubs in universities. Datuk Dr Soon has also stressed the important of playing active role in regional organisations such as the Federation of Asian Polymer Societies and the Network of International Chemistry Educators.

IKM has recognised our Pharmaceutical Chemistry graduates and faculty. To date, a number of our graduates have been awarded the prestigious IKM education award for outstanding academic performance, and one of our faculty also won an IKM-Royal Society of Chemistry Polymer Section award. In addition, some faculty members serve as members of important sub-committees within IKM, and are to be commended for contributing their time and energy to help steer IKM to greater heights.

"On this joyous 10th anniversary, let's celebrate our success in charting a path for the Pharmaceutical Chemistry degree programme in the landscape of quality education. It has been a fantastic experience and I am proud and happy to be part of this process. And let's continue our journey, with renewed commitments, to strive for yet another milestone in the near future. Happy anniversary and congratulations to all!"

A/Prof Dr **Ooi Ing Hong**

The Royal Society of Chemistry (RSC)

Advancing excellence in the chemical sciences

Dr **Wong Lai Chun**, Secretary to the RSC Malaysia Local Chapter and Lecturer, Department of Pharmaceutical Chemistry.

"Unity is strength… when there is teamwork and collaboration, wonderful things can be achieved"- Mattie Stepanek.

It has been a joy and privilege to be a part of the Pharmaceutical Chemistry team for the last five years. Working together, may the Pharmaceutical Chemistry programme reach each even greater heights and success in the future."

Dr **Wong Lai Chun**

The Royal Society of Chemistry's purpose is to advance the chemical sciences – to improve the lives of people around the world now and in the future.

With over 50,000 members and a knowledge business that spans the globe, the Royal Society of Chemistry is the United Kingdom's professional body for chemical scientists, supporting and representing its members, but also bringing together chemical scientists from all over the world.

A not-for-profit organisation with a heritage that spans 177 years, the Royal Society of Chemistry has an ambitious international vision for the future. Around the world, the Society invests in educating future generations of scientists; raises and maintains standards for chemical science professions and knowledge sharing; partners with industry and academia to promote collaboration and innovation; advises governments on policy and promotes the talent, information and ideas that lead to great advances in science.

The membership categories offered by the Royal Society of Chemistry each reflect a particular career stage and level of experience, with focused benefits to match. Membership categories are Student Member, Associate Member (AMRSC), Member (MRSC), Fellow (FRSC) and Affiliate Member. Student Members are an important part of the scientific community and the Society aims to provide them with a strong foundation for a future and career in chemistry. The support available to student members includes career advice, funding for placements and club activities, networking opportunities and access to publications such as Chemistry World. These measures help students to make confident decisions about their future, and help equip them with the right tools to stand out amongst their peers.

Members of all levels may also eligible to apply for awards and funding from the Society. Awards cover a diverse spread of topics, from specialist research to advances in industry and inspirational teaching. Members can apply for grants to support travel, events, outreach and research, as well as personal support and guidance. The Society also awards professional qualifications, such as chartered status (CChem/CSci/CEnv) and professional recognition (RSciTech/RSci) – each for a specific career stage or type. In addition to their academic qualifications, an individual with these credentials demonstrates achievement of Society accredited standards of professional competence, and commitment to the profession.

The important educational role of the Royal Society of Chemistry is accreditation of Bachelors and Masters degrees in the chemical sciences. The Society has undertaken this role for many years both in the United Kingdom and internationally. The IMU BSc (Hons) Pharmaceutical Chemistry programme is one of ten undergraduate programmes in Malaysia accredited by the society. Degree accreditation enhances standards in chemistry teaching worldwide. The Society networks and collaborates with its accredited universities to promote chemistry. In 2014, the IMU and the Society co-organised the joint Malaysia-UK Symposium on Natural Product Chemistry and Drug Discovery at IMU Bukit Jalil, Kuala Lumpur. More than 180 delegates representing universities from various countries participated in this symposium. The Society also organises annual career webinar sessions for IMU BSc Pharmaceutical Chemistry students.

The Society hopes to increase its engagement with its members in Malaysia and the local community through the Malaysia Local Section, that supports and serves more than 200 members in Malaysia. The Royal Society of Chemistry places great importance on working closely with its invaluable members, to advance excellence in the chemical sciences.

The American Chemical Society (ACS)

Improving lives through the transformational power of chemistry

Dr **Low May Lee**, Secretary of ACS Malaysia Chapter and Lecturer, Department of Pharmaceutical Chemistry.

> "I treasured the opportunity being part of Pharmaceutical Chemistry team. Every day is like a wonderful growing up adventure to serve something bigger than myself and to make a difference. Happy 10th Anniversary, Pharmaceutical Chemistry Programme! Many, many years of success to come!"
>
> Dr **Low May Lee**

With more than 161,000 members, the American Chemical Society (ACS) is the world's largest scientific society and one of the world's leading sources of authoritative scientific information. A non-profit organisation, chartered by Congress, ACS is at the forefront of the evolving worldwide chemical enterprise and the premier professional home for chemists, chemical engineers and related professions around the globe. ACS' strategic goal is to create a global scientific community that engages members and other scientific professionals to advance science education, research, knowledge, interaction, and collaboration. It offers a wealth of benefits, services and grants to help ACS members (students and chemical professionals) at any stage of their career to achieve their goals.

The Malaysia International Chemical Sciences Chapter was officially established on 15th April 2014 with the principal mission to provide a platform for all ACS members in Malaysia to interact with each other with following purposes: (1) communicating chemistry and chemical technology effectively among the members and also with general public; (2) establishing a strong and professional relationship with ACS Units, such as ACS International office and other International Science Chapters and ACS Divisions, and (3) assisting the Society to accomplish its international strategic plans. Currently, there are more than 250 active ACS members in Malaysia. It is reassuring to see that the Chapter has attained tremendous achievements over the years such, as the ACS Salute to Excellence Award and ACS Partner for Progress and Prosperity Medal. In addition, the Chapter has been active in international and national events including the ACS Asia Pacific International Conference 2017; the International Conference for Young Chemists; the Global Innovation Imperatives International Symposium on Contaminants of Emerging Concern 2017; the ASEAN Global Innovation Challenge 2017; and outreach programmes such as the Chemistry Festival.

The ACS has a strong ongoing association with our University. The Society supported the Introduction to Global Chemists' Code of Ethics Chemical Safety and Security workshop that was held in IMU last year with participation from Pharmaceutical Chemistry and Pharmacy students, graduate students and faculty.

The Dean of the School of Pharmacy, A/Prof Dr Mohd Zulkefeli Mat Jusoh is a members of the Chapter's National Advisory Board. The Chapter was formed upon members' foundation and strength and will continue to strive for greater heights. All are welcomed to be part of the Society and to contribute to the work of the Chapter. There will be much excitement ahead to work together in improving lives and achieving mutual goals.

Internships: Springboard to the Real-World

Dr **Keng Pei Sin** and Dr **Cheong Kok Whye**, Former and Current Programme Directors of the BSc (Hons) Pharmaceutical Chemistry.

"2018 marked the 10th anniversary for the Pharmaceutical Chemistry programme. I truly cherished every moment that I shared with colleagues, students and alumni for the past 10 years. It is because of these WONDERFUL people, the programme has achieved a significant milestone. Let's get together to celebrate this memorable achievement and wish everyone many more years of success."

Dr **Keng Pei Sin**

Internships or work-based placements are integral to an effective curriculum, as they provide structured learning in actual work settings, during which students apply, integrate and further elaborate their knowledge and skills. For many students, university classes can be quite theoretical and abstract. Therefore, internships are their first opportunity to experience the hands-on aspects of their study, and to see and address real-world problems in the context in which these problems occur. Research has shown significant improvements in undergraduates' perceived performance of employability traits following internship experience. These traits include effective communication; self-awareness and self-management; critical thinking; analysing data using technology and problem solving; initiative and enterprise; social responsibility and professionalism. Apart from providing invaluable experience, work-based learning provides students insights into employers' expectations, future career pathways and opportunities; helps students establish industry contacts and networks; and generally enhances graduand employability.

In the Pharmaceutical Chemistry Programme, internships particularly provide work-based learning in the chemical and pharmaceutical sectors. Since the establishment of the programme in 2008, continuing effort has been taken to enhance this workplace learning experience, including increasing its duration, creating international internship opportunities and increasing the number of training partnerships and sites with industry companies.

When the programme was started, only 6 weeks of workplace learning was offered. Feedback elicited from students, alumni and industry partners clearly indicated that longer internships are preferred by all parties, and are expected to achieve greater benefits. In the curriculum review of 2012 a minimum of 8 weeks of placements was implemented. In the 2017 curriculum review this was increased to at least 4 months, in line with the programme mission to prepare work-ready graduands.

In addition to this curriculum requirement, individual students take the initiative to explore opportunities for workplace learning outside Malaysia. Programme faculty staff and the University facilitate this through the University's Student Mobility Programme. International placements bring the added advantages of helping students develop cross-cultural skills and sensitivity, confidence and independence, and enable students to make international contacts. Work experience outside Malaysia is a plus for any resumè. To date Pharmaceutical Chemistry students have undertaken internship experience in England, India, Singapore, Uganda and Tanzania. Students have said that experience in different work settings and living abroad have made them understand the importance of communication, managing their learning, and ultimately crafted a greater vision of their profession. Here are thoughts from students who had the opportunity to undergo internship abroad.

Hovah Marie Emilie Leiticia, an international student, undertook an internship with Clearsynth, a well-established chemical company in Hyderabad, India. Emilie shared that making the decision to do the internship outside Malaysia was not an easy one because it meant stepping out of her comfort zone. According to Emilie

"Becoming part of a company usually involves more professionalism, accountability and responsibility. I was not part of the IMU cocoon anymore and I had to become a more independent person which was quite challenging at first. But, all this is part of the learning process and IMU did bestow me with the necessary tools to survive in the industry, be it in terms of knowledge or professional attitude. I must say going to India for my internship was a good move for my career. I definitely learnt a lot, more than I ever expected. I can say that I now have the confidence and experience I never had before."

Emelie (PC1/12)

Bavani Rajan (PC1/13) recalled the time she spent abroad during her internship at Simpor Pharma, a pioneering pharmaceutical and nutraceutical manufacturing plant in Brunei.

"It has proven to be an invaluable experience for me, and is certainly a great stepping-stone. It was a big challenge to step up and take up the initiative to do my internship abroad. Anyway, I rate my internship as the best thing that has happened to me professionally. I am truly blessed being trained in the emerging and rapidly growing field of Halal pharmaceuticals. Joining this programme is definitely one of the best decision that I have made and it has built my professional network."

Gladys Yap Zi Yu (PC1/14) did her internship at the Centre of Biomolecular Science (CBS) at the University of Nottingham, United Kingdom. Working as a research assistant for a collaborative project between IMU and CBS researchers enabled Gladys to acquire new laboratory skills, and gave her opportunities to acquire experience with advanced instrumentation. Gladys shared some advice, *"Since I was not working in a company, I was allowed to have extremely flexible working hours. Despite the freedom and trust given by my supervisors, I always disciplined myself to complete my daily task on time."* She also agreed that interning abroad has given her the opportunity to visit places with different cultures and meet people of different backgrounds which add value to her cross-cultural skills and sensitivity.

"It was challenging to travel so far alone and be open minded to get to know people from different backgrounds. Stepping out from my comfort zone has gained me a lot of fun and challenges. I appreciate everyone I met in both work and travel throughout these months."

The internship programme has now been ongoing for ten years, and had helped build close relationships with various industrial partners. At the time of writing, the programme has arrangements with 50 companies and research institutions, both in and outside Malaysia, to provide placements. These sites include companies involved in pharmaceuticals and cosmeceuticals, chemicals and oleo-chemicals; research and development organisations; and biotechnology and analytical laboratories. The School continues to pay serious attention to engaging with and developing effective relationships with industry partners. The first School Stakeholder Meeting in August 2017 enabled industry representatives to share their views on the internships and graduand work readiness and provide feedback on the curriculum. Many of the relationships with industry are formalised as Memoranda of Agreement that provide for collaboration in workplace learning; and product research and development. At the time of writing companies who have signed such Memoranda include Novartis Corporation (M) Sdn Bhd, Novugen Pharma Sdn Bhd, Novo Nordisk Pharma (M) Sdn Bhd, Zuellig Pharma Sdn Bhd, and Innovax Sdn Bhd. The programme and School wish to thank all our industry partners for their continuing support and engagement with our educational mission. The programme will continue to work closely with industry.

Photo of Gladys (right) at the University of Nottingham

01

02

03

01
MoU Signing Ceremony between IMU and Novartis Coporation

02
MoU Singing Ceremony between IMU and Novugen Pharma

03
School of Pharmacy Stakeholder Meeting 3 August 2017


CHAPTER
04

Achievements

Student Achievements

Internal Awards

Book Prize

PC1/08: Ha Ming Joon

Tun Zahir Merit Award

PC1/09: June Sim Su-Way
PC1/10: Yap Chai Hong
PC1/11: Chong Ming Kang
PC1/12: Hovah Marie Emilie Leiticia
PC1/13: Zhang YuXin
PC1/14: Cheng Miaw Chin

Dean's List of Graduands with High Academic Achievement

PC1/09: June Sim Su-Way, Lee Jia Yin
PC1/10: Yap Chai Hong, Lee Pei Sian
PC1/11: Chong Ming Kang
PC1/12: Hovah Marie Emilie Leiticia
PC1/13: Zhang YuXin, Chuah Chong Ho, Tey Hui Yin, Wong Zheng Wei
PC1/14: Cheng Miaw Chin

Best Interprofessional Learning Poster Award

PC1/15 & PC2/15: Toh Tzi Shin, Caryn Loo Kar Yan, Vu Dinh Duong, Chong Siew Xian, Yap Pui Mun, Liaw Pu Kang, Eddie Yii Chung Ann, Ho Keat Zhee

IMU Learning Festival 2017

Video Competition First Prize

PC1/15: Caryn Kar Yan Loo, Khye Qie Chew and Tzi Shin Toh

Students' Choice for Best Video Presentation

PC1/15: Caryn Kar Yan Loo, Khye Qie Chew and Tzi Shin Toh

External Awards

Malaysian Chemistry Institute (IKM) Graduate Chemistry Medal

2014: Chong Ming Kang (PC1/11)
2015: Hovah Marie Emilie Leiticia (PC1/12)
2017: Cheng Miaw Chin (PC1/14)

Brand's Smart Achiever Award

2017: Wong Xi Khai (PC1/17)

Publications

PC1/13

Authors: Xin Yu Leong, Punniyakoti Veeraveedu Thanikachalam, Manisha Pandey, Srinivasan Ramamurthy

Publication: A systematic review of the protective role of swertiamarin in cardiac and metabolic diseases. Biomedicine and Pharmacotherapy, 84 (2016) 1051–1060.

PC1/13

Authors: Zheng Wei Wong, Punniyakoti Veeraveedu Thanikachalam, Srinivasan Ramamurthy

Publication: Molecular understanding of the protective role of natural products on isoproterenol-induced myocardial infarction: A review. Biomed Pharmacother. 94 (2017), 1145-1166.

PC1/14

Authors: Qian Yi Eng, Punniyakoti Veeraveedu Thanikachalam, Srinivasan Ramamurthy

Publication: Molecular understanding of Epigallocatechin gallate (EGCG) in cardiovascular and metabolic diseases. Journal of Ethnopharmacology, 10 (2018), 296-310.

PC1/14

Authors: Hui Meng Er, Marcus Kuek Jia Ming, Pei Sin Keng, Vishna Devi Nadarajah

Publication: Pharmacy Students' Perceptions of Reflective Portfolios, and the Effect of the Portfolio on Students' Deep Information-Processing Skills. American Journal of Pharmaceutical Education (2018).

Conference Presentations

Year	Name of Conference	Title of Presentation	Oral/Poster	Authors	Remarks
2017 (PC1/15)	National Health Professionals Undergraduate Research Conference 2017 (IMU), Malaysia	Microbes Cultivation on the Developed Thin-Film Agar	Poster	Dinh Duong Vu, Tzi Shin Toh, Rachael Chin Nee Lim, Kai Ern Goh, Yun Khoon Liew	Best Poster Presentation
2014 (PC1/12)	Controlled Release Drug Delivery Symposium 2014 (CRDDS 2014), Malaysia	Development of Cefuroxime Axetil Loaded Fibrin Sealant Matrix for Local Treatment of Periodontitis	Oral	Ravi Sheshala, Tai Chieh Hwa, Chong Ming Kang, Foh Pei Wen, Venkatalakshmi Ranganathan, Pulikkotil Shaju Jacob, Allan Coombes	-
2013 (PC1/11)	The 3rd International Conference on Pharmacy and Advanced Pharmaceutical Sciences, Indonesia	Formulation and evaluation of antimicrobial potential of topical formulations containing Helianthus Annuus	Poster	Ravi Sheshala, Lee Pei Sian, Yap Chai Hong, Priyathachini, Adinarayana Gorajana, Kamal Dua	-
2017 (PC1/14)	Fundamental Science Congress 2017 (UPM), Malaysia	Removal of Tartrazine from Aqueous Solution Using Honeydew Rind	Poster	Mohamad Shazeli Che Zain, Keng Pei Sin and Teo Chian Ying	-
2017 (PC1/14)	Fundamental Science Congress 2017 (UPM)	Preparation and Characterization of Poly(lactic acid)/Oleate-modified Layered Double Hydroxides Nanocomposites	Poster	Kah Jin Wong, Yoon Yee Then, Choy Sin Lee and Buong Woei Chieng	-

Staff Achievements

2011

- **Dr Lee Choy Sin** and **Dr Mai Chun Wai** secured the 2011 MTSF Science & Technology Research Grant.

2014

- **Dr Wong Lai Chun** secured a Research Fund worth £4000 by the Royal Society of Chemistry (RSC).

2015

- **Dr Mai Chun Wai** was awarded Sultan Mizan Antarctic Research Foundation (YPASM) Research Fellowship 2015 for an attachment at British Antarctic Survey (BAS), Cambridge.
- **A/Prof Dr Ng Chew Hee** secured a Fundamental Research Grant Scheme (FRGS) from the Ministry of Higher Education to work on metal complexes-nanoparticles conjugates.

2016

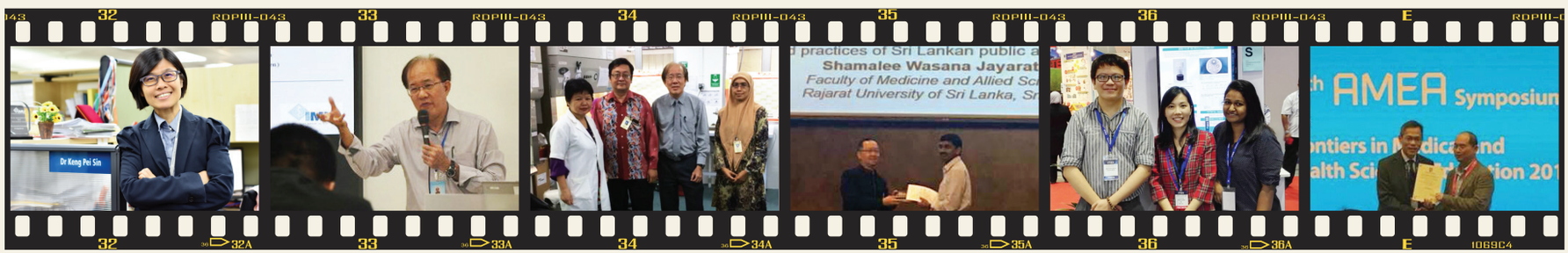
- **Dr Mai Chun Wai** received travel Scholarship from Malaysian Pharmaceutical Society (MPS) to attend Federation Asian Pharmaceutical Association (FAPA) Congress, Bangkok 2016, received Southeast Asia-European Union-NET II (SEA-EU-NET II) Fellowship to visit University of Liverpool (UK) and Chulalongkorn University (Thailand); received research mobility Grant supported by Biochemical Society (UK), British Pharmacological Society (UK), Royal Society of Biology (UK) and Royal Society of Chemistry (UK) to visit as researcher at Institute of Protein Biochemistry, National Research Council, Naples, Italy.
- **Dr Then Yoon Yee** received a Joint IKM & RSC Prize in Polymer Science during the IKM's Annual Chemistry Night.

2016

- **Dr Keng Pei Sin** secured a Research Fund worth £3900 by the Royal Society of Chemistry (RSC).
- **A/Prof Dr Ng Chew Hee** won the Best Oral Presenter Award at the International Conference on Materials Science and Nanotechnology Conference (ISMST) in Seoul, South Korea.
- **A/Prof Dr Ng Chew Hee** and team won second prize in the Biomedical Category for the poster competition at the National Institutes of Health (NIH) Week.

2017

- **Dr Srinivasan Ramamurthy** and team won best poster presentation award at the 1st ASEAN Medical Education Conference (AMEC) in Bangkok, Thailand.
- **Dr Lee Choy Sin** and team won the silver medal at the International Invention and Innovation Exhibition (ITEX).
- **A/Prof Dr Kang Yew Beng** was awarded the "Audience Choice Award-Oral Presentation" at the 9th AMEA Symposium cum Frontiers in Medical and Health Sciences Education 2017 in Hong Kong.



2017

- **Dr Mai Chun Wai** secured a Fundamental Research Grant Scheme (FRGS) for pancreatic cancers.
- **Dr Low May Lee** was one of the four Malaysians chosen to represent the nation at the ACS Global Chemists' Code of Ethics Trainer Leadership Institute in Melbourne, Australia.
- **Dr Teo Chian Ying** secured the 2017 MTSF Science & Technology Research Grant.

2018

- **Prof Mallikarjuna Rao Pichika** has been admitted to Fellow of the Royal Society of Chemistry.


CHAPTER
05

Departmental Activities


01

01
CPD 2010: High Performance Liquid Chromatography (HPLC).


02

02
Professional Education Advisory Committee (PEAC) 2015 in IMU with Prof Yeoh Peng Nam (front row, fourth from right), our former Dean, School of Pharmacy and our current Dean, A/Prof Dr Mohd Zulkefeli Mat Jusoh (front row, third from left).


03

03
Briefing and hands-on activities during IMU annual Students Exploratory Workshop (SEW) event.


04

04
The organising committee for Chemistry Fiesta 2016.


05

05
Chariofare 2015.

06

07

08

09

10

06
RSC accreditation: Katie Dryden-Holt (RSC) presented the certificate to IMU's Vice President, Prof Peter Pook in 2014.

07
RSC visit to IMU in 2016.

08
Meeting with Galway-Mayo Institute of Technology on opportunities for undergraduate industrial placements in Ireland in 2017.

09-10
Joint Malaysia – UK Symposium on Natural Product Chemistry and Drug Discovery and RSC ChemCareers 2014 event co-organised by IMU and the Royal Society of Chemistry (RSC).

11
PharmChem Sc Career Day 2017.

12
PC2/15 and PC1/16 attended a webinar session which jointly organised by the Royal Society of Chemistry (RSC) of UK and the Department of Pharmaceutical Chemistry in 2017.

13
PC2/15 to PC2/17 attended the Introduction to Global Chemists' Code of Ethics (GCCE), Chemical Safety and Security Workshop 2017 which was jointly organised by the American Chemical Society (ACS) and the Department of Pharmaceutical Chemistry.

14
School visit to SMK Bandar Baru Seri Petaling with PC1/12 (CSR 2012).

15
2017 Industrial/ Training Sharing by PC1/14 with Ewe Kheng Huat, Executive Director of Pharmaceutical Association of Malaysia.

16

17

18

16
Retirement party in 2010 for the late Dr Mak Kok Fee, a Pharmaceutical Chemistry programme founder.

17
Alumni Homecoming 2017, (PC1/09, PC1/12, PC1/13).

18
Prof Michael Rathbone, our former Dean School of Pharmacy and Prof Mallikarjuna during the School's year end workshop 2012.


CHAPTER
06

Staff

Present Staff

It has truly been a pleasure and privilege to be part of the committed, hardworking, friendly and dedicated Pharmaceutical Chemistry team on the 10th anniversary of BSc (Hons) Pharmaceutical Chemistry programme. It is heartening to note that the programme has grown from strength to strength and has achieved accreditation at the National and International level.

Happy 10th Anniversary and best wishes for many more years to come!

Dr Srinivasan Ramamurthy
Head of Department (2016-present)

Dr Cheong Siew Lee

It has always been enjoyable for me to work with dedicated colleagues as well as engage with enthusiastic students in the Pharmaceutical Chemistry programme. I take pride in our Pharmaceutical Chemistry family and offer my heartiest congratulations on this significant milestone. Happy 10th anniversary to the Pharmaceutical Chemistry programme!!

Dr Chin Swee Yee

Being part of the team for 8 years, it has been an incredible ride. I'm honoured to be part of the team and witness this meaningful celebration. Congratulations on 10 successful years and many more years of success.

Dr Lee Choy Sin

Congratulations to the School of Pharmacy and Pharmaceutical Chemistry family on its 10th Anniversary celebration of Pharmaceutical Chemistry programme! What a remarkable accomplishment! Thank you everyone for the first 10 years and I am looking forward to many more years to come!

Dr Mai Chun Wai

Congratulations to all of us in achieving the 10 years of success. I am confident we will reach to a greater heights in the coming years.

Dr Murugesh Kandasamy

It's a great pleasure and honour to be a part of the Pharmaceutical Chemistry department at IMU. The department offers the only Royal Society of Chemistry accredited course in Malaysia, integrating an industrial approach with academic content. The system management shapes me and to integrate education with research. I wish the 10th Anniversary to be a grand success and look forward to a bright future.

Dr Ng Sook Han

Congratulations, congratulations, congratulations! My toast to the continuous success for the progressive education in the Pharmaceutical Chemistry programme. Happy 10th Anniversary and best wishes for another 10 years and beyond!

Dr Punniyakoti Veeraveedu Thanikachalam

It is my great pleasure and honor to be a part of the Pharmaceutical Chemistry team, IMU, and to work with dedicated colleagues. The 10th Anniversary marks a significant milestone for all of us. My heartiest congratulations for the Pharmaceutical Chemistry programme.

Dr Ramu Meesala

I am so glad to be part of the IMU Pharmaceutical Chemistry family. I have enjoyed my stay in IMU since I arrived in 2014, working with dynamic, committed and helpful faculty of the Pharmaceutical Chemistry department. I would like to congratulate all the faculty and students who have taken part in the journey towards celebrating this 10th Anniversary.

Former Staff

Dr Sreenivasa Rao Sagineedu

The 10th anniversary marks a significant milestone for all of us and it's wonderful to be part of this memorable journey. Best wishes to everyone for many more successful years ahead.

Dr Teo Chian Ying

This is my third year in IMU. I am happy to be part of the Pharmaceutical Chemistry team and to see the students grow. Looking forward to create more success in the coming years with colleagues in the team.

Dr Then Yoon Yee

This is an exciting year for Pharmaceutical Chemistry department as the programme marks the 10th Anniversary. This milestone is the perfect time to reflect on our outstanding achievements and celebrate the success of our students, staff, alumni and partners. Congratulations on a wonderful accomplishment!

Dr VasudevaRao Avupati

Dear Pharmaceutical Chemistry Department, Congratulations on your programme's 10th Anniversary!

This celebration is a festive day for me and my colleagues. I'm very fortunate to be a part of this event, and I hope it will be an incredible occasion that all participants will remember for a lifetime.

Dr Chee Chin Fei

IMU is a great place to learn, not only for students but also for academic staff. As a lecturer, I learned to teach more efficiently in IMU.

Dr Thirumurugan Rathinasabapathy

I am very much enthused to write to express my profound gratitude to the Pharmaceutical Chemistry department. My days in the Department were a wonderful experience because the Department is a learning hub for teamwork, professionalism and life-long learning. I truly appreciate our Department's valuable role in building a brighter future for Malaysia's next generation. I wish the Programme a successful 10th Anniversary! Keep up this outstanding performance!

Dr Kenny Chan Kam Seng

Congratulations!

Dr Pran Kishore

It is my pleasure and privilege to congratulate the Pharmaceutical Chemistry department on the 10th Anniversary of the Pharmaceutical Chemistry programme. May all individuals in the Department keep inspiring each other, and work in synergy to achieve many glorious milestones ahead.

Dr Lee Siang Yin

I would like to thank IMU for the opportunity to be a member of the Pharmaceutical Chemistry (PC) department team for the past five years. Being part of the PC team has given me many pleasant memories to cherish as I move into another phase of my career. Best wishes to the PC team for continued success.

Dr Arockia Babu

I feel proud to state that I was a part of developing the curriculum for the BSc in Pharmaceutical Chemistry. Presently, this Programme serves as most useful for many young minds of IMU pertaining to their career amelioration. Furthermore, this Programme facilitates employment in many core areas including Medicinal Chemistry, Synthetic Chemistry, Analytical Chemistry etc. I wish the Programme all the best, and continuing success.

Dr Thangaraj Devadoss

It gives me immense pleasure to extend my heartiest felicitations to the PC department, on the occasion of the programme's 10th Anniversary. I proudly recall my association with the team. The hard work, strong professional skills, unparalleled motivation and outstanding performance of the entire team moved the programme to this glorious place.

Supporting Staff

Mohammad Syaufiq Shahril

Congratulations to PC team for this 10th anniversary celebration. I am very pleased to be part of it indirectly and wish all the best for the future.

Hew Siew Pei

It's fun to run practical with curious students especially when they are able to obtain their ideal results (eg. manage to make silly putty, a polymeric silicone). Their satisfaction is my satisfaction also.

Juay Harn Li

It is a pleasure working with the PC team. Together we make sure students get essential skills, knowledge & hands-on experience through practical sessions.

Imerpal Singh Grewal a/l Jogindar Singh

It has been a great pleasure working with the Pharmaceutical Chemistry lecturers throughout my tenure here. They have been helpful in sharing their knowledge and skills during practical sessions. It has been a great experience serving the PC students and watching them grow throughout their semesters.

Tan Hui Chiat

It is a great experience for me to be part of the team and to see how the PC programme has grown to year 10. I am so proud that I am part of the process of training PC students in laboratory skills and competencies, cohort by cohort.

Sharon San Phaik Wah

I have been Administrator for the School of Pharmacy for two years and I am thankful for all the opportunities that were given to me.

I enjoy working with Pharmaceutical Chemistry faculty members as all of them are very friendly and helpful.

Pharmaceutical Chemistry Programme Contributors

Department of Pharmaceutical Technology

Dr Farrukh Zeeshan

Dr Hira Choudhury

Dr Jithendra Panneerselvam

Lim Wei Meng

Dr Manisha Pandey

Dr Nagashekhara Molugulu

Dr Shadab Md

Dr Thiagarajan Madheswaran

Pharmaceutical Chemistry Programme Contributors

Department of Life Sciences

Dr Chong Chun Wie

Dr Dinesh Kumar Chellappan

Dr Gan Sook Yee

Dr Gurbind Singh

Dr Hazwanie Hashim

Dr Ho Ket Li

Jestin Chellian

Prof Leong Chee Onn

Dr Liew Yun Khoon

Dr Mayuren Candasamy

Prof Ong Chin Eng

Dr Subrat Kumar Bhattamisra

A/Prof Dr Tan Eng Lai


CHAPTER
07

Students

Community Projects

01

02

03

04

05

01
PC1/09 at Bukit Nanas Green Plantations for tree planting.

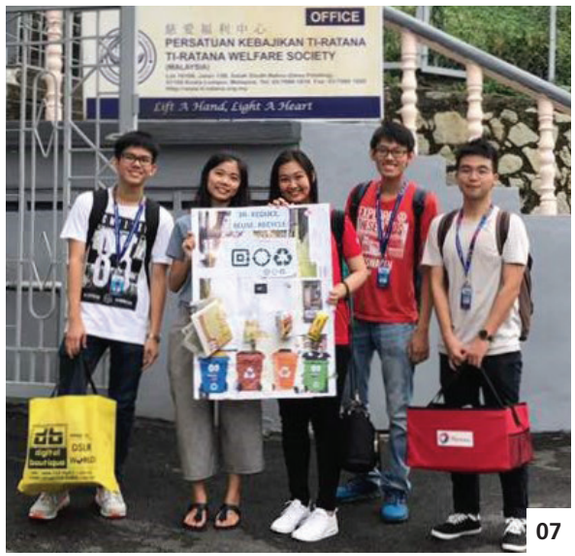
02
PC1/14 tree planting activity as part of Environmental Chemistry module requirement.

03
PC1/12 at Taman Tun Dr. Ismail park, Kuala Lumpur for the raising awareness on clean water.

04
PC1/14 Toxicology community service at SK Kota Kemuning 2 to raise primary school students awareness of toxins.

05
PC1/11 Think Green, Think 5Rs (Recycle, Reuse, Reduce, Restore, Replenish) event in IMU.

06



07

08

09

06
PC1/10 at Teluk Kemang Beach, Port Dickson for beach cleaning.

07-08
As part of studying environmental chemistry and toxicology, PC2/17 conduct public awareness activity about environmental pollution.

09
PC1/16 visit Rumah Charis Children Home.

Industrial Visits


01


02


03

04

05

01
PC1/12 at University Putra Malaysia (UPM).

02
PC1/17 at Malaysia Nuclear Agency (Nuclear Malaysia).

03
PC2/16 at Hovid.

04
PC2/15 at Malaysia Palm Oil Board (MPOB).

05
PC1/13 at Chemical Company of Malaysia (CCM).

Class Pictures and Graduation Ceremonies

01

02

03

04

05

01
PC1/08

02
PC1/12

03
PC1/13

04
PC2/15

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PC2/16

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PC1/11

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PC1/15

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PC2/17

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PC1/09

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PC1/11

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PC1/12

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PC1/13

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PC1/14


CHAPTER
08

Alumni Speak...

Alumni Speak...

Zhang YuXin (PC1/13)

I am Stanwin from PC1/13 In the two years years since graduation I have been a formulation chemist in Q & Z Cosmetics Manufacturing Sdn Bhd, a skincare beauty product manufacturer in Malaysia. My key roles are in formulating new products, production scale up, quality assurance of finished products, product marketing as well as product registration. A key mission Q & Z is to provide green, environmental-friendly, safe and satisfying products of the finest quality and high efficacy. When I started I found my role very challenging as most of the tasks were new to me and were more on industrial aspects. In fact, this causes me even facing more challenges especially in developing new products and scaling up.

Fortunately, I was able to cope with my tasks and I believe one of the most important reasons is the basic knowledge that I gained during my Pharmaceutical Chemistry degree. To be honest, I only realised the importance of some seemingly uncommon modules when I was doing my jobs. For example, Pharmaceutical Engineering, a module related to the design, construction and operation of pharmaceutical-related facilities. It is surprisingly useful when it comes to handling manufacturing machines. Another very applicable example is Microbiology. It's not common to have a chemist who also has a basic knowledge of microbiology but student of IMU's Pharmaceutical Chemistry programme do. I am very grateful for the diversified modules in my degree programme which prepared me with wide knowledge to cater for more opportunities.

I would say working and studying are totally different aspects of life. Studying is not to prepare us for only work but prepare ourselves for our future, and most importantly, self-improvement. In IMU, with their outcome-based learning system and all kinds of instruments and facilities, I believe students are well-equipped with all the necessary basic knowledge and can become ready for professional roles. My life during degree studies definitely forms one one of my deepest memories. I really enjoyed the different activities, friendly lecturers, industrial visits and the professional culture of IMU.

I am happy to be an IMU alumnus and one of the chemists in my company. With the capability and opportunity given, I hope that I am able to contribute and bring a better and more beautiful lifestyle to our society.

Wan Hoon Mun (PC1/11)

This programme has provided me the fundamental knowledge and skills, which helped to enhance my product development techniques in my career path in pharmaceutical company.

Michele Tan (PC1/13)

IMU's Pharmaceutical Chemistry programme is a good stepping stone to enter the pharmaceutical industry. It equips us with the necessary skills, knowledge and gave us exposure to the real world setting of pharmaceutical industry as a whole. It is definitely an interesting and fulfilling journey and I enjoyed it the past 3 years. I never regret joining the programme!

Goh Kai Ern (PC1/15)

I appreciate that the Pharmaceutical Chemistry programme has made me more disciplined and prepared me for work in pharmaceutical industry. Glad to have bunch of good friends in PC1/15, dedicated and patient lecturers to guide us along three years of our university programme.

Toh Tzi Shin (PC1/15)

I'm always glad to be one of the students in IMU. Besides theory, I was also exposed to various soft skills that help to shape me as a competent candidate in the industry. Everyone here was helpful and friendly. This makes my life in IMU to be really wonderful and memorable.

Caryn Loo Kar Yan (PC1/15)

It's my pleasure to be a pharmaceutical chemistry student in IMU. The course not only prepared me for the pharmaceutical industry, but has the flexibility to apply my knowledge in other industries such as the cosmetic industry. The lecturers and friends are always willing to help me throughout my degree journey.

Chong Siew Xian (PC1/15)

I am always very grateful to be one of pharmaceutical chemistry students.
My experience as a Pharmaceutical Chemistry student has, overall, been positive as lecturers and friends are always willing to help.

Heng Yi Xin (PC1/14)

The things taught in IMU are not an education, but the means to an education.

Mohamad Shazeli bin Che Zain (PC1/14)

Pharmaceutical Chemistry has prepared me with fundamental knowledge of drug discovery and development. These basic theories instils passion and drives me to pursue higher level studies to gain more knowledges and hands-on experience. Here I am today continuing my studies in Master of Science in phytochemistry in a top-notch university in Malaysia.

Fabian Mok Ping Xiang (PC1/09)

As an IMU Pharmaceutical Chemistry alumnus, I am privileged to say that my three years in IMU gave me the knowledge and skills to pursue the career in Chemistry that I craved. Our graduates not only enjoy great recognition from the IMU brand but proven professionalism, shown in the generations of fellow alumni who now grace the working world.

"An investment in knowledge pays the best interest"

Benjamin Franklin

Liaw Pu Kang (PC2/15)

The IMU Pharmaceutical Chemistry Programme brings back several best memories to me, such as the good practical sessions and the visits to various industries. I would like to thank to all the lecturers that taught me when I was studying in this course.

Ho Keat Zhee (PC2/15)

It consists of long days and sleepless nights but the fight was well worth it as I've gained so much knowledge and experience throughout the PC course. A huge shout out of thanks to the lecturers who have guided us through these past years!

Michelle Lee Jia Yin (PC1/09)

To be honest, when I first joined the Pharmaceutical Chemistry programme, I just wanted to join an interesting course related to chemistry. I never really thought about what job I would be doing in the future, and really never even saw myself working in the same field of study. However, everything changed over time. The time spent in the university changed this; it instilled interests and soft skills which are very useful now.

Ong Chih Yean (PC1/10)

A strict, well-structured and diversified programme. Stressful, challenging yet interesting with lots of cool friends and lecturers. With love and unhappy feelings in between but no doubt,
I miss all these.

Alexis Jiou Su-Xian (PC1/11)

One of my best IMU moments was volunteering to help the United Voice, an organisation for children with learning disabilities. When my classmates and I joined this programme during Year 2, I experienced extraordinary bonding and friendships that last until today. Most importantly, this experience led me to develop a heart of giving. Until today I'm still involved in volunteer work to give back to society.

Ha Ming Joon (PC1/08)

The time spent in IMU was a flash. It seemed an instant but glowed in my life. An unforgettable memory.


CHAPTER
09

Congratulatory Messages

From RSC Malaysia

ROYAL SOCIETY OF CHEMISTRY | MALAYSIA LOCAL SECTION

Datuk Dr Soon Ting Kueh FRSC
Chair

Associate Professor Dr Mohd Zulkefeli bin Mat Jusoh
Dean
School of Pharmacy
International Medical University
No.126, Jalan Jalil Perkasa 19
57000 Kuala Lumpur

16 April 2018

Dear Associate Professor Dr Mohd Zulkefeli bin Mat Jusoh,

On behalf of the Royal Society of Chemistry Malaysia Section, we are delighted to extend our warmest wishes to the School of Pharmacy, International Medical University on the 10th Anniversary of the BSc (Hons) Pharmaceutical Chemistry programme.

This is indeed an important milestone in the programme since its establishment as the first programme in Malaysia that provides undergraduate training in Pharmaceutical Chemistry. We congratulate the school on its tremendous growth over the last 10 years, and wish you many more achievements in the future.

Best wishes and regards.

Yours sincerely,

Datuk Dr Soon Ting Kueh

Chair, Royal Society of Chemistry Malaysia Section

From ACS Malaysia

ACS
Chemistry for Life®

April 26, 2018

Assoc. Prof. Dr. Mohd Zulkefeli Mat Jusoh
School of Pharmacy
International Medical University (IMU)
No. 126, Jalan Jalil Perkasa 19
Bukit Jalil, 57000 Kuala Lumpur

Dear Assoc. Prof. Dr. Mohd Zulkefeli

Congratulatory Message for IMU Pharmaceutical Chemistry Programme's 10th Anniversary

On behalf of ACS Malaysia Chapter, I am delighted to extend my warmest congratulations to you and your team for IMU Pharmaceutical Chemistry Programme's 10th Anniversary.

This is truly a memorable milestone and I am certain that the programme will continue to shine in the future.

We are proud to be associated with the university through our members and we look forward to more ventures to work together across chemistry boundaries in improving lives.

My very best wishes

Dr. Lee Hooi Ling
Chair
Malaysia International Chemical Science Chapter
American Chemical Society

From RSC UK

Congratulations to IMU and all involved in the BSc (Hons) Pharmaceutical Chemistry programme. As a professional body for the chemical sciences we accredit this programme for partially meeting the academic requirements for Chartered Chemist. As part of this process we reviewed learning outcomes evidence, and visited IMU to meet staff and students. It was clear that the programme met the needs of its students and also importantly for future employers. In addition the commitment the university makes to developing its students with skills outside of science and interacting with other organisations is impressive. I wish you all well and look forward to visiting you all in 2019.

Toby Underwood MChem CChem
Manager, Accreditation & Careers

From IKM

INSTITUT KIMIA MALAYSIA
MALAYSIAN INSTITUTE OF CHEMISTRY
(Inaugurated on 8 April 1957, Incorporated under Chemists Act 1975 on 1 November 1977)
127B, JALAN AMINUDDIN BAKI, TAMAN TUN DR. ISMAIL 60000 KUALA LUMPUR.
FAX : 03 - 7728 9909 TEL : 7728 3272 (HUNTING LINE)
WEBSITE : http://www.ikm.org.my EMAIL: ikmmy@pc.jaring.my

Congratulatory Message

International Medical University – Pharmaceutical Chemistry Programme
10th Anniversary Celebrations 2018

On behalf of Institut Kimia Malaysia (IKM), I would like to congratulate International Medical University for the success of the Pharmaceutical Chemistry programme for the last 10 years.

In 2008, IKM was involved in the drawing up of the curriculum of the Pharmaceutical Chemistry programme in the School of Pharmacy, International Medical University (IMU). Subsequently, this programme was first launched on 14th July 2008 with its first cohort of 20 students. After ten successful years, we are indeed pleased with the high standard and success of this pharmaceutical chemistry programme in IMU.

Institut Kimia Malaysia, or IKM as we are popularly known, is a statutory professional organization incorporated under the Chemist Act 1975 on 1st November 1977. Over the last fifty years, IKM has grown in tandem with the rapid development of Malaysia to become a well-established and strong professional organization recognized both locally and internationally. The Vision of the Institute is "Advancing Chemical Sciences and Professionalism in Chemistry for Knowledge Generation, Wealth Creation and Improving the Quality of Life".

Membership of IKM comes from both the manufacturing and service sectors, universities and other institutions of higher learning, research and development institutions, and government and education sectors. With a membership of 4,226 as of May 2018, IKM enjoys a prominent place among the professional scientific organizations in Malaysia. The Institute is also playing a leading role in the development of chemical sciences in Malaysia.

Among the industries in Malaysia, the pharmaceutical industry is relatively new. I believe that IMU can play a key role in the development of this industry in terms of human resource development. We need to promote research and development in pharmaceutical science and chemistry to support the further growth and development of this sector. In fact, the Malaysian government has identified the domestic pharmaceutical industry as an industry to be developed and promoted under the new economic transformation programme. Both IKM and IMU can play a key role here.

Once again, I extend our heartfelt congratulations to the Pharmaceutical Chemistry Department, International Medical University for 10 years of success and progress in the Pharmaceutical Chemistry programme.

I wish you continuing success in the programme.

Datuk Dr Soon Ting Kueh
President, Institut Kimia Malaysia


CHAPTER
10

Moving Forward

Pharmaceutical Chemistry: Moving Forward

Dr **Cheong Kok Whye**, Programme Director, BSc (Hons) Pharmaceutical Chemistry.

> "I would like to congratulate the School of Pharmacy and the Pharmaceutical Chemistry department on its 10th Anniversary celebration of the Pharmaceutical Chemistry programme. An outstanding programme cannot be built overnight, and hence I am grateful to be part of this amazing team and celebration. Coming together is the beginning, keeping together is progress, working together is success."
>
> Dr **Cheong Kok Whye**

In 2008, the IMU introduced the Pharmaceutical Chemistry programme, in response to the governmental initiative to promote pharmaceutical industry as strategic to national development. More recently, research and consulting company GlobalData estimated the pharmaceutical market in Malaysia to grow from USD 2.3 billion in 2015 to USD 3.6 billion by 2020. It was also in 2008, healthcare reforms and a world recession prompted countries providing government funded healthcare towards generic medicines. This trend is set to continue as branded small molecule drugs and biologics continue to come off patent. Taken together, these factors predict that the demand for pharmaceutical chemists will remain high, if not grow. But will our pharmaceutical chemist graduands be up to the challenge posed by ongoing rapid technological change?

Higher education faces ongoing challenges of meeting changing and evolving workplace expectations of knowledge, skills and attitudes. Many Malaysian employers report basic deficiencies in these areas.

Then there is the daunting challenge of developing graduands fit to lead or even participate in the fourth industrial revolution (IR 4.0). To address this, the 2015-2025 Blueprint for Higher Education was formulated to cultivate holistic graduates who are knowledgeable, skilled, talented, adaptable and able to take on the challenges in the 21st century, including jobs "that are yet to exist". One initiative is the implementation of the integrated cumulative grade point average (iCGPA), that reports holistic attainment based on students' learning experiences in tertiary education. Hence, the iCGPA reports learners' attainments of attributes as outlined in the Malaysian Education Blueprint: Ethics and Spirituality, Leadership Skills, National Identity, Language Proficiency, Thinking Skills and Knowledge; and in the eight learning outcome domains of the Malaysian Qualifications Framework. To address the needs of IR 4.0. the Ministry of Education has also introduced a range of initiatives such as the 2u2i Programme and the CEO@Faculty Programme.

Powered by artificial intelligence, advances in robotics, virtual reality, cloud technology, big data, and the internet of things, IR 4.0 is said to be characterised by a fusion of technologies, integrating physical, digital and biological domains. In recent years, educationists have recognised the profound impact of internet and communications technological innovation on education. 'Technology enhanced learning' is increasingly used in the delivery of educational programmes.

For example, the Pharmaceutical Chemistry programme uses i-lectures, flipped classrooms, gamification, e-formative assessments, and workplace simulations before students undertake real workplace based learning.

However, technology enhanced learning may do little to change the essential nature, or model on which educational programmes are based. Higher education as we know it has undeniably contributed significantly to today's continuing advances in science and technology. It is thus imperative that we fundamentally re-assess our models of educational delivery. It is also imperative to ask if we doing enough to equip future generations with the empathy and the human elements needed in a technological age. IR 4.0 requires digitally literate individuals who are also able to tap into their creativity; who are innovative, cognitively flexible, critical and analytic, able to deal with complexity, and entrepreneurial. The processes of learning, and the strategies of teaching need to fundamentally change, both now and in the foreseeable future. For example, to enable personalised learning, programmes of study can be unbundled, and instructional strategies can adapt to the learning needs of upcoming generations. Learning analytics can provide insights into cognitive processes and predict instructional strategies. But are institutions, students and teachers ready for fundamental change?

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