Transformative Science
Education | Research | Enterprise

STAYING AHEAD OF THE FUTURE

ANNUAL REPORT 2017

NUS
National University of Singapore

Faculty of Science
VISION
To be among the world’s best in science education and research

MISSION
To provide quality education, foster the spirit of enterprise and conduct leading-edge research to advance knowledge in Science and Technology for the benefit of Singapore and the global community
In 2017, we successfully carried out the Faculty’s core mission to provide quality education, foster the spirit of enterprise and conduct cutting-edge research. We embrace a culture of excellence where all of us, staff and students alike, have the opportunity to be the best that we can be.

Transformative Education
Apart from reinforcing the teaching of fundamental science, we have enhanced our preparation of students for the workplace by offering more opportunities to learn new skills and take up internships. In addition, the Faculty is implementing a specially designed Cooperative Education Programme for Data Science and Analytics students. Interweaving study and work, the programme allows students to gain valuable practical working experience without having to lengthen their candidature.

Dean's Message
Development of a culture of excellence will be the key to elevate us to the next level of achievement. We need to move beyond helping our students acquire and apply knowledge, to nurturing within them skills and passion to be lifelong learners.

Our new Second Major in Data Analytics extends data science training to students of other disciplines, preparing them to meet the rising demand of graduates who understand data analytics.

We also increased our suite of academic programmes to provide students with the necessary breadth and depth of educational training to face an increasingly complex and ambiguous future. To this end, the Faculty is expanding its multidisciplinary programme offerings, because solutions to next generation problems will need a multidisciplinary perspective. The new Second Major in Food Science and the M.Sc. in Food Science and Human Nutrition are examples in this direction.

We have enlarged our network of overseas partners and put up a host of programmes that leverage on niche academic areas in individual institutions. For example, we will offer a Joint Degree Programme with the University of Dundee (UoD) which allows our Life Sciences students to study drug discovery and design, a flagship programme in UoD. We are also opening up additional avenues for student exchange with some of these partner universities, focusing on research projects and research-based internships.
Transformative Research

In terms of research, the Faculty continues to push the boundaries to go beyond being a global competitor, towards the goal of being a global leader. We focus on integrating strengths in niche research areas, emphasising innovation with long-term impact, and developing translational research that has local relevance. For instance, in this report, you will see that our research projects directly impact diverse areas, such as water quality in Singapore’s waterways and reservoirs; healthcare policy and solutions; invention of materials for better performance in industrial applications; the fight against human diseases; and assurance of food security. The Faculty is poised to make significant research contributions that will benefit Singapore as well as advance scientific knowledge.

Giving

The Faculty launched its Science Merit Scholarship fundraising initiative in April this year. This initiative will benefit our students as they will have access to more scholarships. We are deeply grateful to the many generous donors who have supported us, allowing us to garner more than 30 scholarships within a few months. The fundraising continues in earnest as the Faculty strives to draw the most capable students to study Science at NUS.

Looking Ahead

Building a culture of excellence within the Faculty will be the key for us to elevate to the next level of achievement. We need to move beyond merely helping our students acquire and apply knowledge. We need to nurture within them skills and passion to be lifelong learners who think deeply, ask questions, and discover new knowledge. In research, we will further develop our strengths in niche areas and encourage more interdisciplinary and translational research, particularly those with local relevance. With our talented students and staff, we shall work together towards the goal of being a global leader in science research and education.

Prof SHEN Zuowei
Tan Chin Tuan Centennial Professor
Dean, Faculty of Science
If your actions inspire others to dream more, learn more, do more and become more, you are a leader. ~ John Quincy Adams
We affirmed our standing as a faculty at the forefront of transformative science education and cutting-edge research. The year’s key milestones included the launch of several academic programmes, inaugural student and alumni initiatives, as well as the establishment of the Data Analytics Consulting Centre.

Year in Review

New postgraduate programmes
The M.Sc. in Chemistry for Energy and Environment programme, covering the latest energy and environmental technologies, admitted its first cohort this year (see pgs 20 and 24). The M.Sc. in Food Science and Human Nutrition programme will provide in-depth knowledge of advanced topics in food science subdisciplines (see pg 20). The M.Sc. in Quantitative Finance programme will be offered to working professionals in China (see pgs 20 and 26). These two programmes will be offered from August 2018.

The Data Analytics Consulting Centre (DACC)
The newly launched DACC offers consulting services and executive courses, and collaborates with industry partners to unlock the value of Big Data for business growth. Its outreach programme aims to raise awareness of new career and business opportunities in the fast-growing data science sector, and to expose students to real-world data-driven problems (see pg 18).

Cooperative Education Programme
From Academic Year 2017/2018, Data Science and Analytics students can opt for credit-bearing internships under this programme, where they gain on-the-job experience by relating studies to real-world issues. Students spend five semesters/terms with various reputable employers during their third and fourth years of study. This enhances their employability after graduation (see pgs 18 and 32).

New B.Sc. (Hons) in Pharmaceutical Science programme
The new Pharmaceutical Science (Hons) Major programme will be offered from Academic Year 2018/2019. Graduates will acquire niche knowledge of the drug discovery and development process, as well as the regulatory and commercial environment of the business (see pg 28).

New Second Major programmes
The Second Major in Data Analytics, offered from Academic Year 2017/2018 for cohort from Academic Year 2016/2017 and after, incorporates interdisciplinary learning from computer science, mathematics and statistics. Students acquire skills to tackle data-related issues at the workplace.

The Second Major in Food Science for Chemistry students, which covers the multidisciplinary nature of food science, will be offered through direct admissions from Academic Year 2017/2018. Food chemistry and flavour science modules provide training and applied perspectives in these areas. Nutrition-related modules will cover food aspects beyond physical and chemical properties (see pg 24).
Grant award for Marine Science Research and Development Programme (MSRDP)

The Faculty obtained grant funding under the MSRDP, for three years from 1 August, from the National Research Foundation Singapore. This will be used to set up the MSRDP Overseas Programme Award for more students to work on marine science research overseas. The MSRDP comprises four themes: marine ecosystems and biodiversity, environmental impact and monitoring, coastal ecological engineering, and marine technology and platforms.

New exchange programmes

A Joint Degree Programme with the University of Dundee (UoD) enables Life Sciences students to study drug discovery and design at UoD. We are collaborating with the University of Melbourne to offer a Concurrent Degree Programme, encompassing a B.Sc. (Life Sciences)-Doctor of Veterinary Medicine. We also established new Student Exchange Programmes (SEPs) with the University of Tokyo in environmental studies and the Norwegian University of Science and Technology for Pharmacy students. Undergraduate Research Opportunities Programme in Science (UROPS)-SEPs with Zhiyuan College, Shanghai Jiao Tong University and St John’s College, University of Cambridge open up research-based internships (see pg 9).

Inaugural graduating cohort

Two-time valedictorian Nisha MOHD RAFIQ is the first graduate of the joint Ph.D. in Biological Sciences between NUS and King’s College London. Nisha co-authored four research papers for her Ph.D. She conducted research on the mechanical signalling in podosomes for insights into the migration of cancer cells. She also chaired the prestigious Gordon Research Seminar in 2016 (see pg 16).

Science Merit Scholarships

The Faculty embarked on a strategic initiative to raise 100 NUS Science Merit Scholarships, launched at a dinner graced by then President Dr Tony TAN in April (see pg 40). We held a fundraising carnival at the Lee Kong Chian Natural History Museum on 11 November, which drew more than 1,400 visitors (see pgs 34 and 40). NUS Chemistry’s 88th Anniversary dinner on 27 October raised over $200,000 towards the Chemistry Alumni Fund, which also supports the Huang Hsing Hua Chemistry Merit Scholarship (see pg 25).

30th International Young Physicists’ Tournament (IYPT)

Team Singapore, comprising Markus LENDERMANN and LI Kang Chen (NUS High School of Mathematics and Science), and WANG Huaijin, Rachel PANG Qing and FU Xinghong (Raffles Institution), emerged the champion. Singapore hosted IYPT (2017), one of the world’s foremost physics competitions, for the first time from 5 to 12 July (see pg 31).

5th Asia Environment Lecture

On 3 November, Ms Patricia ZURITA, Chief Executive Officer of BirdLife International and a global sustainability expert, shared how birds and their flyways illustrate world connectivity and show a path to conservation. She also discussed how empowering local communities can support the global agenda of addressing environmental challenges.
NUS-Dow Surprising Science Workshop

For the first time, the Science Demonstration Laboratory, Department of Chemistry and Dow Chemical Pacific (Singapore) Pte Ltd collaborated to give 30 teachers from 19 schools a perspective of science’s impact on society. At the Chemistry Week workshop, teachers engaged Young Educators in Science members on experiments and classroom teaching ideas. They also visited Dow Consumer Solutions’ Laboratory to observe industrial product demonstrations.

Data Science and Analytics Day

The event on 15 March gave students insights into the fast-growing data science sector and its practical applications. Mr TAY Yu Xuan, a Statistics alumnus, shared how data science transforms the delivery of government digital services and builds Smart Nation capabilities. Mathematics alumnus Dr YANG Liuqin, Data Scientist, Grab (formerly GrabTaxi), discussed how data science drives Grab’s operations (see pg 27).

INAUGURAL EVENTS

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INAUGURAL STUDENT EVENTS

NUS Quant Challenge

The competition in March enabled participants to apply their quantitative finance skills in formulating investment strategies. The teams competed in building mathematical models to predict the future movements of financial instruments. The event was hosted by the Faculty and the School of Computing, and sponsored by WorldQuant, LLC (see pgs 19 and 33).

Singapore Frontier Challenge (SFC)

Team SAVEZ, comprising Physics students SEAH Zong Long, KOH Jun Hao and CHAN Si Min, and two Engineering students, were among the finalists of the SFC (2017) which concluded on 30 September. Participants were mentored by SP Group experts to develop alternative energy solutions. Team SAVEZ developed a solar cell fabric and a transparent solar cell to convert sunlight into energy. SFC 2017 was spearheaded by the NUS Physics Society.

Internet of Things (IoT) Datathon

The Faculty and weather technology company Terra Weather co-organised the Datathon as part of Science Industry Day (2017). The teams were mentored by industry experts to develop IoT data-driven applications to address problems faced by small and medium enterprises. The winning team developed an algorithm that automates the maintenance of a solar photovoltaic system (see pg 19).
Life Sciences alumna Ms Nur Yusrina YA’AKOB received Berita Harian’s Young Achiever of the Year Award (2017). In May, she became the first Singaporean Malay woman to scale Mount Everest, the world’s highest peak, as a member of the NTU-NIE Everest Team Singapore. The award is presented to Malay/Muslim individuals who have shown perseverance, integrity and the ability to overcome the odds.

At the NUS Alumni Awards 2017, Emeritus Prof Louis CHEN, Founding Director of NUS’ Institute for Mathematical Sciences (IMS) was conferred the Distinguished Alumni Service Award for his service to NUS and contributions to the advancement of science. He built up IMS into one of the finest institutes in the world and his research work on the Chen-Stein method has grown into one of the most important areas of discrete probability.

Prof CHUA Nam Hai, Professor (Plant Molecular Biology), the Rockefeller University, received the Distinguished Alumni Service Award, for his many original contributions to plant cell and developmental biology.

Dr NEO Mei Lin, Marine Biologist at NUS’ Tropical Marine Science Institute, received the Outstanding Young Alumni Award for her world-recognised research on giant clam ecology and behaviour, and marine conservation.

Inaugural winner in national green certification scheme

The Chemistry Laboratory at the Tahir Foundation Building was conferred the Building and Construction Authority (BCA)’s Platinum award under the BCA Green Mark for Laboratories scheme - the world’s first green certification scheme for laboratory designs and operations. NUS is the first education institution in Singapore to receive the award. Green features at the Chemistry Laboratory include energy-efficient fume hoods, special ventilation for heat-generating equipment and thermostat-controlled air-conditioning of individual laboratories (see pg 25).
Advancing Global Collaborations

New degree programmes
The Faculty signed a Memorandum of Understanding with the University of Dundee (UoD) on 2 November 2016 which opened opportunities to more mutual academic and scientific research options for staff and a Joint Degree Programme (JDP). The JDP enables NUS Life Sciences students to study drug discovery and design at UoD. UoD’s Life Sciences students can study Neurobiology, Human Physiology and Functional Ageing, or Genetic Medicine at NUS.

We are collaborating with the University of Melbourne to offer a Concurrent Degree Programme (CDP), encompassing a B.Sc. (Life Sciences)-Doctor of Veterinary Medicine. Students will acquire theoretical, practical and clinical training in veterinary medicine and veterinary science. The CDP integrates the two degree programmes, so that students can accelerate and complete the programme in 5½ years (see pg 6).

New student exchange programmes (SEPs)
The Faculty established an SEP with the University of Tokyo (UTokyo) for five years, from 17 March. This provides a unique opportunity for Environmental Studies and Faculty students to read courses at UTokyo’s PEAK (Programmes in English at Komaba).

We established an Undergraduate Research Opportunities Programme in Science (UROPS)-SEP with the elite Zhiyuan College, Shanghai Jiao Tong University for five years, from 2 May. A similar programme was established with St John’s College, University of Cambridge on 18 September. These agreements open up research-based attachments and internships for students from NUS and the partner universities.

Under an SEP with the Norwegian University of Science and Technology (NTNU) established on 14 August, NUS Pharmacy students will undertake a final year research project at NTNU, on diagnostics and therapy, health promotion, prevention and management, and technology systems, welfare technology and health services organisation. NTNU students will undertake a year-long Masters research project at NUS (see pg 6).
Our Transformative Science Education equips students to be future-ready through specialised domain expertise and transferable skills. Our flexible curriculum also gives students myriad choices to enrich their learning experiences.

**Holistic global education**

Study Abroad Programmes (SAPs) with over 300 overseas partner universities open the door to a global learning experience, exposing students to different cultures and academic environments. This broadens their intellectual and global outlook.

LIM Jie Ai, Year 4 Food Science and Technology, participated in the NUS Overseas Colleges (NOC) programme in Israel. At The Kitchen FoodTech Hub, part of the Israel Innovation Authority’s incubator programme, she learnt to build a food technology ecosystem from scratch. At Flying SpArk, a startup which develops sustainable alternatives to animal protein, she farmed fruit fly larvae to produce quality protein powders. She said, “I gained insights into extremely innovative and cutting-edge food research.”

LAN Yingjie, who graduated among the top of his class in 2017 from the prestigious NUS-Waseda Double Degree Programme, said, “I gained both depth and breadth from the contrasting insights into the sciences and the arts.” Yingjie read Life Sciences at NUS and Linguistics at Waseda’s School of International Liberal Studies. This prepared him well to teach English and Biology in schools.

**Flexible curriculum**

We revamped our undergraduate curriculum to accommodate Unrestricted Elective space for students to explore additional areas with significant depth. The increased flexibility enables students to plan their learning pathways, for instance, through self-structured double degrees.

Year 4 student ZHANG Jingwei is pursuing a Double Degree Programme in Applied Mathematics and Economics. He said, “Economics extends mathematical models and methodologies to solve real-life problems, like efficient pricing or scarce resource allocation.”
Summer Programmes enrich students’ learning experiences without disrupting their academic schedules.

Daniel TAY, Year 3 Physics, attended the Leiden Summer School, where he was exposed to cutting-edge topics in physics. He said, “The programme presented physics with a new yet familiar twist and drew multidisciplinary connections to chemistry and biology, including the emerging field of biophysics.”

Pamela YEH, a Life Sciences graduate (2017) who was from the inaugural Applied Project module cohort, interned at animal welfare organisation Save Our Street Dogs. She said, “I was uniquely placed to integrate scientific knowledge of animal behaviour and the practical aspect of working with dogs at an animal shelter.”

Nicole LIM, Year 3 Environmental Studies, participated in the NUS Study Trips for Engagement and EnRichment (STEER) programme, where students study the socio-cultural-economic environments of fast-evolving regions. On her field trip to Costa Rica, she said, “I learnt about sustainability practices, like how they achieved a 98% renewable energy mix.”

TOON Jun Hao, a Chemistry graduate (2017), pursued the Joint Minor Programme in Environmental Chemistry at the University of Toronto. He said, “I am intrigued by the chemistry behind environmental changes. This fuels my passion to protect the environment.”

Angela CHAN, Year 4 Environmental Studies, was amongst the pioneer batch of students in the Student Exchange Programme at Cornell University College of Agriculture and Life Sciences. She said, “The campus’ natural setting was a great way to study nature in-situ. I also learnt to think critically about norms in university life.”

Fazrina SALAUDDIN, Year 3 Statistics, read the Forensic Science module at the King’s College London Summer Programme, where she learnt to analyse crime scenes, differentiate drugs and find DNA matches. She said, “I now understand how forensic statisticians apply probability models to DNA evidence and the law.”
The Faculty, together with the Ministry of Education (MOE) and other partners, runs numerous pre-undergraduate research programmes, competitions, workshops, school visits, talks as well as our flagship event, the Faculty Open House. These programmes promote and sustain public awareness and interest in science education and encourage students to read Science at NUS.

**Attracting Young Talents**

**Mathematical treats at Science Summer Camp**
The 2017 camp welcomed over 120 students and nine teachers, who were treated to engaging hands-on science activities and mathematical puzzles prepared by the Young Educators in Science Mathematics Focus Group. These mathematical treats involved real-life application problems in graphs and game theories. An activity on celestial mechanics also saw participants enjoy a tour through the night sky in a portable planetarium.

**Science Research Programme (SRP)**
The 1\(\frac{1}{2}\)-year SRP, co-organised with MOE, has nurtured budding researchers for the past 29 years. Selected students were mentored by NUS faculty and staff from other institutions on research projects. They presented their findings at the 29th Science Research Congress on 29 April. Their projects bagged three Gold Awards, five Silver Awards, five Bronze Awards, four Merit Awards and one Special Award (Action Community for Entrepreneurship) at the Singapore Science and Engineering Fair (2017).

**Science talks and Masterclass lectures**
As part of our outreach programme to pre-university and polytechnic students, the Faculty gave talks to students of local institutions like Innova Junior College (JC), Victoria JC, NUS High School of Mathematics and Science, and Temasek Polytechnic. The talks offered a glimpse of the depth and diversity of learning opportunities here, such as our multidisciplinary and cross-faculty programmes, undergraduate research programmes, internships, student exchange programmes etc., as well as the career prospects of Science graduates.
Nan Hua High School visit
On 18 January, the Faculty hosted students and teachers from Nan Hua High School. Prof GOH Say Song, Vice Dean of Outreach and Admissions, shared on the Faculty’s Transformative Science Education. Dr NG Ngan Kee, Department of Biological Sciences, touched on Singapore’s biodiversity and its historical, scientific and economic value, while Prof SOW Chong Haur, Head, Department of Physics, captivated the audience with various demonstrations to illustrate physics concepts.

Department engagement activities
In April, the Departments of Biological Sciences, Chemistry, Mathematics, Physics, Statistics and Applied Probability, as well as the Data Science and Analytics, and the Food Science and Technology Programme Offices organised half-day visits over two weeks for prospective students who received admission offers to study Science at NUS. The students participated in hands-on activities, laboratory tours, talks and meetings with faculty members which gave insights into our Science majors and career prospects of our graduates. Initiated in 2016, this pre-admission event encourages acceptance of the offers.

Learning Journey at the Mathematics Department
This event has been organised since 2015 for junior college (JC) students, to introduce them to NUS Mathematics-related courses, as well as to create awareness of its relevance and applications. In 2017, students from 14 JCs toured the department and listened to enrichment talks on the H2 Mathematics curriculum. They also learnt how to use Maple software to plot graphs and toured the department (see pg 27).
Our students achieve excellence beyond the classroom in areas ranging from sports to community service. They contribute in meaningful ways to the NUS community and society at large.

Celebrating Student Achievements

Sports champion
Elisa Yukie YOKOYAMA, Year 2 Environmental Studies, was part of the women’s national sailing team who clinched gold at the 29th Southeast Asian (SEA) Games (2017), in spite of a shoulder injury. Elisa also received the gold for the female 420 race at SEA Games (2015), Sportsgirl of the Year Award (2013) from the Singapore National Olympic Council (SNOC), and the SNOC Meritorious Award (2016). She has represented Singapore in international competitions, like the Youth World Sailing Championships and the Optimist World Championship (2012) where she came in first. She hopes to qualify for the 2020 Summer Olympics.

Environmental advocate
As President of NUS Students Against Violation of the Earth (NUS SAVE) in Academic Year 2015/2016, Elaine SAM, an Environmental Studies graduate (2017), managed campaigns to promote environmental sustainability.

Community leader
Founded in 2011, NUS Enablers organises programmes to help students with special needs (SSNs), one of the first initiatives of its kind among Singapore tertiary institutions. SOH Si Lin, Year 4 Life Sciences, its President in Academic Year 2016/2017, ran activities to raise awareness of the challenges faced by SSNs and promote their integration into campus life. This included the Para-Sports Carnival recognising the ‘Olympian’ resolve of SSNs through games. NUS Enablers also works with the Disability Support Office to provide peer support and specialised equipment for SSNs.

She co-chaired the National Environment Agency (NEA)’s Youth for the Environment Day (2015) which aimed to reduce plastic waste. To tackle food waste, she co-founded the NUS Buffet Response Team in 2017 to alert people to excess food on campus. The group now has more than 6,000 members who were alerted to at least 110 buffets. Elaine received NEA’s EcoFriend Award (2015), and the Ten Accomplished Youth Organisations ASEAN Award (2016) on behalf of her NUS SAVE team.
Postgraduate student achiever
Dr YU Tingsheng received the Chua Toh Hua Memorial Gold Medal (2017), awarded to Life Sciences Ph.D. graduates for outstanding research. Tingsheng contributed to understanding the molecular control of bone formation in teleost fish. Her study established that the medaka fish is a suitable animal model for analysing human bone diseases. Her work was published in the prestigious Development journal (January 2017). She is now a postdoctoral scholar in Orofacial Sciences at the University of California, San Francisco.

Young researchers
Five students received the Outstanding Undergraduate Researcher Prize (2017), which recognises the best undergraduate researchers in NUS.
Life Sciences’ LEONG Jun Hao engineered natural killer (NK) cells, a cell subtype with anticancer activity, to better target and kill cancer cells, opening possibilities for new NK cell-based immunotherapy.
Life Sciences’ TA Le Duc Huy studied how nasal microbiota in infants affects childhood respiratory health.
Food Science and Technology’s Alcine CHAN developed a unique sour beer with high probiotic live counts, to provide health benefits like improved gut health.
Pharmacy’s Donavan Marcus NEO developed antivirals for Chikungunya fever, a tropical disease which currently lacks licensed drugs or vaccines (see pg 29).
Physics’ Daniel TAY fabricated a spintronic system where incoming microwaves interact with magnetic spins, and showed how this device can control microwave transmissions.

Budding entrepreneur
OOI Gene Yan, a Quantitative Finance graduate (2017), co-founded Shentilium Technologies in 2016. This NUS spinoff combines deep learning and Artificial Intelligence to create solutions for companies in diverse industries. One of the winners of BNP Paribas International Hackathon (2017), the financial industry’s biggest worldwide hackathon, the startup plans to expand beyond Singapore.
STAYING AHEAD of the Future

[1. PARTICIPATE IN A NEW SCIENTIFIC ERA]
“We are fortunate to be more than just witnesses but also participants in scientific achievements, from Artificial Intelligence to Smart City solutions and precision medicine.”
- Dr WEN Jun, Ph.D. in Statistics and Applied Probability

[2. FORGE AHEAD WITH HUMILITY]
“Humility gives us confidence for the future as we remain open-minded and grateful that every step of our journey ahead is not taken for granted.”
- WONG Zi Heng, Honours (Distinction) in Physics

[3. PUSH THE ENVELOPE OF KNOWLEDGE]
“Science is an intrinsically human endeavour, the quest to explore the unknown, scale new peaks and push the boundaries of human knowledge.”
- Dr John OUYANG Fengcong, Ph.D. in Chemistry

[4. REACH FOR GREATER HEIGHTS]
“Fall and fail, but more importantly, make every failure a lesson towards something even bigger and useful for society at large.”
- Dr Nisha MOHD RAFIQ, Joint Ph.D. in Biological Sciences, NUS-King’s College London

[5. HELP OTHERS REALISE THEIR ASPIRATIONS]
“Be strong and help others emerge triumphant. We can make a change through small gestures delivered with great love.”
- LIM Dah Wei, Honours (Highest Distinction) in Pharmacy

[6. THINK OUT OF THE BOX]
“The rigour of scientific education allows us to discern concrete proofs from alternative facts, appreciate the intricacies in a creative solution, digest abstract problems and derive elegant solutions.”
- KHOR Shi-Jie, Honours (Highest Distinction) in Mathematics

[7. DARE TO DREAM]
“Pursue your dreams – make the world a better place for everyone.”
- Edwin CHAN, Honours (Highest Distinction) in Life Sciences

Valedictorians

As our valedictorians embark on an exciting new chapter in their lives, they share their perspectives on preparing for the future.
Our students continue to give back to society. They contribute to numerous meaningful causes, making a positive difference to disadvantaged communities.

Project Angel: Mosaic of Hearts
From 19 May to 6 June, 17 student volunteers visited Cambodia to help underprivileged communities. At Widow’s Island, they conducted English lessons, installed irrigation systems and cemented the Vocational Training Centre’s walls. At Sa’ang Community Education School, they conducted English lessons, helped with construction work and organised a cultural exchange to share on Singapore’s multiethnic cuisine and festivals.

RAG (Receive and Give) and FLAG
This year, more than 430 Science students participated in Flag Day on 8 August. They raised more than $17,400 for our beneficiary, the Lions Befrienders Service Association (Singapore), which cares for seniors. The Science RAG team clinched the Silver award for their performance.

NUS Day of Service
To support the tradition of giving back to the community, the Faculty came together and volunteered for Community Chest’s Heartstrings Walk (2017) on 9 September. More than 60 students, staff and alumni participated in the Fun Walk. They conducted fun carnival activities to raise awareness of the special needs community. The proceeds went to more than 600 beneficiaries. Science students, together with Healthserve and the Straits Times School Pocket Money Fund, organised games and sports for 35 migrant workers at Westlite Mandai Dormitory. Food Science and Technology alumni participated in World First Aid Day (2017) organised by Red Cross Singapore, where they distributed emergency packs to beneficiaries at Taman Jurong Community Centre.

The event, which promotes volunteerism in the Faculty, was held from 6 to 10 March. It featured different themes which guided its activities. These included appreciation notes for school cleaners and construction workers on the day of ‘Loving’, and a collection drive to support ‘Giving’.

Project DNA
Student volunteers collaborated with the Clementi Youth Executive Committee to help financially needy families living in Clementi rental flats. They conducted a survey to collect household information and raised $4,600 for provision packs which were distributed to some 100 families on 6 and 7 May.
The Data Analytics Consulting Centre (DACC) helps clients to generate value from data using cutting-edge techniques and advanced data analytics strategies. This makes businesses smarter, more productive and more competitive.

Transforming Businesses with Big Data

Consultancy and courses
With our industry-leading software applications and training programmes, businesses can acquire and retain customers; automate data cleaning and data preparation processes; create new business models; create new and innovative products and services; enhance revenue generation; manage risk; and optimise operations and performance.

Partnerships
We work with industry partners and organise engagement events to facilitate the adoption of leading-edge data-driven solutions that solve business challenges. Through the DACC, businesses can also tap on the multidisciplinary expertise of our professors.

Our programmes also provide students exposure to real-world data-driven problems through events like hackathons etc. In addition, our Data Science and Analytics undergraduates can participate in the Cooperative Education Programme which integrates studies with on-the-job learning through internships. This enhances students’ employability after graduation (see pgs 5 and 32).

Our Industry Sharing Series features leading industry speakers, who share on workplace challenges, trends and career opportunities. This prepares students for data science-related careers in diverse industries. In turn, our partners enjoy access to a pool of talented students, and opportunities to network with our data scientists (see pg 19).

Outreach
Our outreach programmes aim to raise awareness of exciting new career and business opportunities in the fast-growing data science sector arising from Singapore’s Smart Nation vision.

Our experts
The DACC is headed by Prof Carol HARGREAVES, an analytics and business intelligence professional with over 28 years of analytics experience.

Please contact dacc@nus.edu.sg with a brief description of your business/research problem, for a free one-hour, no obligation consultation.
The Faculty developed strategic collaborations with industries that further strengthened our experiential learning programmes while advancing transformative research that benefits society. Our programmes provide students industry exposure, while employers gain early access to a pipeline of talented students.

**Engaging Industry**

**New initiatives**

During the inaugural Internet of Things (IoT) Datathon, students were mentored by industry experts to develop commercially-viable IoT applications and to transform scientific ideas into solutions for small and medium enterprises. The NUS Quant Challenge in March drew 75 student teams who built mathematical models for predicting the future movements of securities and financial instruments (see pgs 7 and 33).

**Science Industry Day**

Our flagship Science Industry Day (2017), held on 17 March, was enhanced as a one-stop event offering education, research, internship and career opportunities for students, staff and industries. A series of industry talks drew about 200 participants, with speakers from leading organisations like JP Morgan, Seagate Technology, AXIS Re, and the Agency for Science, Technology and Research (A*STAR), to name a few. The event included an industry fair featuring some 30 corporate partners and a Pharmacy workshop on interdisciplinary research in pharmaceutical and cosmetics applications.

**Industry Sharing Series**

Thought leaders from high-impact sectors were invited to share on industry developments and career opportunities. At these sessions, students and faculty members got to dialogue with them. This year, we organised talks by Nielsen on data analytics applications in industry; Works Applications on careers in the software industry; Terra Weather on enhancing competitiveness with digital technology; SAP on intelligent enterprises powered by machine learning; WorldQuant on developing quantitative talent; and The Pique Lab on the private enrichment industry (see pg 18).
We launched various new programmes, enabling our graduates to continue upgrading their skills. Lifelong learning helps our graduates to stay relevant and connected to the world, while adapting to rapid change. Our courses support the SkillsFuture initiative, which empowers Singaporeans with the competencies for professional and personal development.

Learning for Life

New continual learning initiative
Alumni can now read modules for free in the first year, under NUS’ new lifelong learning initiative. From Academic Year 2017/2018, our alumni can take up to two modules over three years, from 28 modules offered in Chemistry, Food Science and Technology, Life Sciences, Mathematics, Pharmacy, Physics as well as Statistics and Applied Probability. No fees are charged in the first year of study. In the subsequent two years, course fees are waived and only a Student Services fee is charged.

Food Science and Technology alumna Ms Mabelyn TAN (left), Development Specialist for infant and specialised nutrition at FrieslandCampina Development Centre AMEA Pte Ltd, is reading the Nutritional Biochemistry module. She said, “Interactive class discussions on the latest scientific topics relating to nutrition and health fuel ideas for research and new product development. This knowledge is highly beneficial in addressing future consumer needs.”

New postgraduate programmes
The Chemistry Department admitted its first cohort of students this year for its new M.Sc. in Chemistry for Energy and Environment coursework programme. Students will gain broad knowledge of the latest energy and environmental technologies, which are important research areas for the development of clean energy sources that support environmental sustainability and liveability (see pgs 5 and 24).

From August 2018, the Food Science and Technology Programme will offer a new M.Sc. in Food Science and Human Nutrition coursework programme. Students will gain in-depth knowledge of advanced topics in food science subdisciplines, like food bioscience, modern food processing technology, evidence-based functional foods and modern analytical science in human nutrition. This will prepare them for the fast-growing global food industry (see pg 5).

From August 2018, the Department of Mathematics, in collaboration with the School of Mathematical Sciences at Shanghai Jiao Tong University (SJTU) will offer a new M.Sc. in Quantitative Finance programme in Shanghai. This is a part-time programme for working professionals in China, to acquire advanced knowledge in quantitative finance. Students will receive an NUS degree and an SJTU certificate upon completion of the programme (see pgs 5 and 26).
Leading

Transformative

Research

The Faculty conducts research to advance knowledge, industry and society. Our researchers continue to win competitive public sector grants and collaborate with universities worldwide, government agencies and industry to develop high-value, high-impact partnerships to transform scientific innovations into solutions.

Studying biological interactions in reservoirs and waterways

The Freshwater and Invasion Biology Research Group led by Prof Darren YEO from the Department of Biological Sciences is strengthening its collaboration with PUB, Singapore’s National Water Agency, through an expanded study of the aquatic biodiversity and ecology in local reservoirs and waterways. This builds on earlier work which first documented the biodiversity in Singapore’s reservoirs, and a pilot study on quantitative biodiversity sampling and food web interactions.

Creating a new healthcare paradigm of disease interception

The Metabolic Profiling Research Group led by Prof Eric CHAN from the Department of Pharmacy is partnering pharmaceutical company Janssen Research & Development, LLC to predict the risk profile for early intervention of urological disease. The project will use systems biology tools and Big Data analytics to investigate disease risk factors.

Advancing the device performance of organic electronics

The Materials Chemistry Research Group at the Organic Nano Device Laboratory led by Prof CHUA Lay-Lay from the Department of Chemistry and also at Physics, partners with chemical company Sumitomo Chemical Co Ltd and Cambridge Display Technology Ltd to develop novel \textit{in-situ} photo- or thermally-activated n-dopants in self-compensated n-doped semiconductor polymers to achieve ohmic electron injection into emerging organic semiconductor materials for lighting applications, including flexible electronics and bioelectronics.

Understanding the epidemiology of skin diseases

The Allergy and Molecular Immunology Research Group led by Prof CHEW Fook Tim from the Department of Biological Sciences partnered dermatology company Galderma Research & Development to study atopic dermatitis and allergy-related disorders in Asians. Companies are interested in deeper characterisation of these diseases to understand the underlying different pathophysiology and to identify new biomarkers and therapeutic targets specifically for Asian populations.
EXECUTIVE SUMMARY

The Department of Biological Sciences continued to strengthen our foundations in research and academic excellence, while enhancing strategic collaborations with industries and academic institutions in Singapore and abroad. Our core disciplines - Biophysical Sciences; Cell, Molecular and Developmental Biology; and Ecology and Evolutionary Biology - are helmed by a team of award-winning faculty members. We also stayed at the forefront of research advances in areas like human healthcare, food security and sustainable development. We also exploit emerging technologies, like high-resolution microscopy, genome editing tools, Big Data analytics, and computational and quantitative tools, to break new ground.

EDUCATIONAL MILESTONES

In 2017, the Life Sciences Major was revised, to offer students a new and more flexible structure. Core foundational modules were reorganised to comprehensively cover Molecular Genetics, Molecular Cell Biology and Evolutionary Biology in Year 1. From Year 2, students can chart their own academic progress with modules covering the full spectrum of Life Sciences disciplines. For the first time, Honours students can undertake applied internship projects or complete coursework-taught modules, apart from the Honours research project. We also expanded our offerings to include a Life Sciences-Management Double Major Programme and a Life Sciences-Public Health Major-Minor Programme.

RESEARCH COMMENTARIES

Fighting tritryp diseases with unique autophagy mechanism

Trypanosoma brucei is a group of eukaryotic pathogens that are responsible for the tritryp diseases in humans and animals, causing an enormous economic and healthcare burden globally. Using Trypanosoma brucei as a model, Prof Cynthia HE’s team investigated the metabolic trigger and induction mechanism of autophagy in this evolutionarily divergent parasite. This work paves the path towards targeting parasite autophagy as new disease intervention approaches.

Engineering cold tolerance in plants

Prof XU Jian’s research uncovers the mechanistic basis of temperature stress tolerance on plant development. This is crucial for more effective plant adaptation strategies to maintain growth and productivity under extreme temperature events from climate change. Translating the outcomes to practical applications in agriculture, he uses rice to assess gene-trait associations across taxonomic divisions, aiming to increase food production capacity and food security. His breakthrough discovery on the specialised responses of plant stem cells to low temperatures was published in Cell (June 2017).
Arresting cancer through energy starvation
A team led by Prof Jayaraman SIVARAMAN has uncovered a way to stop cancer cells in their tracks through energy starvation. Cancer cells expend huge amounts of energy for growth, and are forced to adopt an alternative pathway for energy production, referred to as glutaminolysis (Warburg Effect). The team hypothesised that cutting off this energy source could starve cancer cells and arrest their growth. Through a novel mechanism, they show how the small-molecule BPTES/derivative can specifically bind and inhibit glutaminase, a key enzyme in cancer metabolism, thereby stalling the anabolic pathways of cancer cells. These findings could offer a more potent but less cytotoxic treatment for patients with various types of cancers.

OTHER SIGNIFICANT INITIATIVES

18th International Congress of Developmental Biology
Held from 18 to 22 June, the event in Singapore saw the gathering of distinguished colleagues from the International Society of Developmental Biologists, Plenary Nobel Laureate Lecturers and researchers to exchange ideas and insights on exciting breakthroughs in developmental biology in the world.

Alumni reunion
We celebrated the 20th Anniversary of our founding from the merger of the Departments of Botany and Zoology on 10 March. The classes of 1995 to 1997 were invited to an inaugural alumni reunion dinner. At this memorable event, former and current faculty members reminisced about their college days and veteran professors, Prof Alex IP and Prof TAN Tech Koon, recounted their wonderful memories with their students.

AWARDS AND ACCOLADES

Prof Leo TAN received the Asean Biodiversity Heroes award for his significant contributions to biodiversity efforts in Singapore, and the NUS Outstanding Service Award (2017) for transforming teacher and science education in Singapore. Prof YU Hao was appointed Provost’s Chair Professor (see pgs 35-36).
STAYING AHEAD of the Future

EDUCATIONAL MILESTONES

The Chemistry-Food Science Double Major offered from Academic Year 2017/2018 provides students training and applied perspectives in the multidisciplinary field of food science (see pg 5). We saw the graduation of the inaugural cohort of students who completed their final year internships in applied and industrial contexts in the chemical industry. The newly launched M.Sc. in Chemistry for Energy and Environment equips students with knowledge of the latest energy and environmental technologies (see pgs 5 and 20).

EXECUTIVE SUMMARY

The Department of Chemistry continued to excel in research, with 400 papers published and over $10 million secured in research funding. We further enhanced our students’ learning experience through greater exposure to blended learning. According to Quacquarelli Symonds (QS) World University Rankings, Chemistry at NUS is ranked top in Asia and 7th internationally.

RESEARCH COMMENTARIES

Giant Stark effect in black phosphorus

Two-dimensional (2D) black phosphorus has sparked research interest due to its high carrier mobility and widely tunable direct bandgap. It is one of the few 2D materials where it is possible to tune the bandgap over a wide energy range from the visible to the infrared spectrum. A team led by Prof LU Jiong and Prof LOH Kian Ping demonstrated an electrical field-controlled giant Stark effect in black phosphorus for potential applications in advanced electro-optic devices.

Fighting diabetes with bioactives from tropical plants

Prof HUANG Dejian and his Ph.D. student ZHANG Yan formulated noodles that digest slowly so that blood glucose levels do not change much. These noodles are made with flour and extracts from Malay cherry plant leaves, an edible plant with medicinal properties. The findings are promising to address growing demand from an increasingly diabetic population for starchy foods with a low glycemic index.

Base metal catalysts for sustainable chemical synthesis

Base metal catalysts such as iron, cobalt and nickel have caught on in chemical synthesis due to low cost, low toxicity and high natural abundance. A research team led by Prof GE Shaozhong developed a series of cobalt-catalysed hydrofunctionalisation reactions of unsaturated organic molecules to prepare value-added chemicals from readily available materials. The success in this research field will enable more efficient production of chemical compounds.
KEY EVENTS

9th Singapore International Chemistry Conference (SICC-9)
SICC-9, which attracted some 600 participants, including 330 foreign delegates, was jointly organised with the Singapore National Institute of Chemistry from 11 to 14 December 2016. There were over 300 oral presentations, including eight plenary and 16 keynote presentations by renowned scientists, and about 250 poster presentations.

Chemistry Honours Symposium and alumni networking
The session on 4 April drew over 70 students and staff. Students gained insights from the alumni on preparing for workplace challenges.

49th International Chemistry Olympiad (IChO)
Held in Thailand from 6 to 15 July, IChO drew 297 students from 76 countries. The Singapore team won two gold medals and two silver medals and ranked sixth. Hwa Chong Institution student ZHANG Zhiyuan was awarded the International Union of Pure and Applied Chemistry Prize for the second highest score in theoretical tasks.

AWARDS AND ACCOLADES

Prof LIU Xiaogang was named in the Highly Cited Researchers (2017) report and received the NUS Outstanding Researcher Award (2017) for his groundbreaking research in optical nanomaterials. Dr Adrian Michael LEE received the NUS Outstanding Educator Award (2017) for his innovative integration of technology into education (see pg 36).

Our Chemistry Laboratory was one of the inaugural winners of the platinum awards under the new Green Mark for Laboratories scheme launched by the Building and Construction Authority in May this year (see pg 8).
EXECUTIVE SUMMARY

The Department of Mathematics has made significant progress in our core mission of delivering quality education and research in recent years. Faculty members continued to make impactful scholarly contributions, receiving multiple recognitions internationally.

EDUCATIONAL MILESTONES

The Special Programme in Mathematics grooms top students with the aptitude and passion for mathematical sciences. For the Class of 2017, LEE Si Ying, winner of the Medal of Excellence in Mathematics, will go to Harvard University, and GAO Yuan, winner of the Ho Family Prize, will go to Columbia University, to pursue their Ph.D. degrees. Our students also contribute at international events. Ph.D. student ZHAO Quan and undergraduate ANG Yan Sheng participated in the 5th Heidelberg Laureate Forum from 23 to 29 September in Germany.

From August 2018, the Department, with the School of Mathematical Sciences at Shanghai Jiao Tong University will be offering a new M.Sc. in Quantitative Finance in Shanghai, for professionals in China to acquire advanced quantitative finance knowledge (see pgs 5 and 20).

RESEARCH COMMENTARIES

Resolving fundamental questions on theta correspondence

Theta correspondence is a technique for transferring representations or automorphic forms from one group to another. It has been a useful tool in the Langlands programme as it efficiently constructs automorphic forms with desired properties. To be effective as a tool for constructing automorphic forms, several fundamental problems in the theory need to be resolved. In the past two years, Prof GAN Wee Teck and his collaborators have settled several of these fundamental problems and pushed the boundary of applications of theta correspondence. In particular, Prof Gan and Prof Atsushi ICHINO used the theta correspondence to resolve the Fourier-Jacobi case of the local Gross-Prasad conjecture for unitary groups.
Uncovering complex Hénon maps in higher dimension

Real Hénon maps were introduced by Prof Michel HÉNON as a simplified model for the Poincaré section of the Lorenz model. The associated dynamical systems exhibit chaotic behaviour and are among the most challenging dynamical systems. Two-dimensional complex Hénon maps were studied by many researchers. In higher dimensions, the dynamics become much richer. The lack of tools has been a central difficulty. During the last decade, Prof DINH Tien Cuong and his collaborator Prof Nessim SIBONY developed a theory of super-potentials and a theory of intersection for positive closed currents which allows them to prove fundamental properties of these maps.

Solving Lasso problems efficiently

The Big Data era brings new challenges in analysing massive data with a large number of samples and/or high dimensionality. In response to these challenges, $\ell_1$-regularised least squares regression models (Lasso) are intensively studied. Despite the existence of many Lasso solvers in the literature, there are currently no robust solvers that can efficiently handle difficult large-scale regression problems with real data. Prof SUN Defeng, Prof TOH Kim Chuan and their former Ph.D. student Dr LI Xudong have developed an extremely fast and robust semi-smooth Newton augmented Lagrangian algorithm to solve Lasso problems. For challenging Lasso problems with large-scale real datasets, their algorithm can be over 100 times faster than state-of-the-art solvers.

OUTREACH

Our Mathematics Learning Journey, launched in 2015, introduces prospective students to NUS’ Mathematics and creates awareness of the relevance of mathematics. During the year in review, we organised four learning journeys attended by over 170 students (see pg 13). We also organised a successful Data Science and Analytics Day, where speakers shared with junior college students and the public how mathematical concepts come into play with Grab taxis and driverless cars (see pg 7).

AWARDS AND ACCOLADES

Prof SHEN Zuowei was named in the Highly Cited Researchers (2017) report, and elected as a Fellow of the American Mathematical Society. Prof DINH Tien Cuong was invited as a sectional speaker at the International Congress of Mathematicians (2018) in Rio de Janeiro, Brazil. He was also appointed Provost’s Chair Professor. Prof TOH Kim Chuan was awarded the 2017 Farkas Prize for his fundamental contributions to the theory, practice and application of convex optimisation. Prof GAN Wee Teck received the President’s Science Award (2017) for his work on the Langlands programme and the Gan-Gross-Prasad conjecture (see pgs 35-36).
EXECUTIVE SUMMARY

The Department of Pharmacy’s vision is to lead in shaping healthcare through innovative pharmaceutical education, research and practice. As the only tertiary provider of Pharmacy education in Singapore, we are responsible for ensuring the quality and relevance of our education. Our research in health outcomes and pharmaceutical sciences contribute to creating new knowledge that has impacted society and the profession.

EDUCATIONAL MILESTONES

We launched a full year of experiential learning for Year 4 students, the cornerstone of our transformative new curriculum that was implemented in Academic Year 2014/2015. This comprises a compulsory six-month credit-bearing internship towards professional pharmacists’ registration, as well as a Final Year Project (FYP). For the latter, we collaborated with the Centre for English Language to launch a novel FYP which is amalgamated with Scientific Communication. This framework is designed as a testbed for using student-specific research experiences as the context for learning about scientific writing.

The new Pharmaceutical Science (Hons) Major programme will be offered from Academic Year 2018/2019. Graduates will acquire niche knowledge of the drug discovery and development process, as well as the regulatory and commercial environment of the business (see pg 5).

RESEARCH COMMENTARIES

Combating drug-resistant bacteria
Antimicrobial drug resistance has emerged as one of the most serious threats facing mankind today. Prof Rachel EE and her team developed de novo design strategies for multifunctional antimicrobial peptides targeted against clinical isolates of drug-susceptible and multidrug-resistant bacteria. Notably, these peptides promoted the disruption of pre-formed drug-resistant biofilms and effectively neutralised endotoxins at low micromolar concentrations. Overall, the team’s design strategies could provide a useful tool for developing therapeutic peptides for clinical use.

Boosting stem cell numbers for transplantation
In research led by Prof Christina CHAI, Prof Gigi CHIU and Prof William HWANG from the Singapore General Hospital and Duke-NUS Graduate Medical School, a novel small molecule which boosts the number of stem cells in human umbilical cord blood was discovered. This discovery is significant as this can be used in clinical transplantations to treat various blood-related diseases. The use of the novel small molecule also has the competitive advantage of simplifying existing procedures in processing umbilical cord blood for transplantation, thus reducing time and cost. This research work was funded by the Singapore-MIT Alliance for Research and Technology Innovation Grant. A provisional patent has been filed for the technology.
Influencing drug-induced liver injury by gut bacteria

A multidisciplinary research team led by Prof Eric CHAN employed an integrated strategy combining pharmacokinetics, toxicology, metabolomics, genomics and metagenomics to interrogate the role of the liver-gut microbiota axis in underpinning the hepatotoxicity of tacrine in Lister-hooded rats. Their study established the pertinent gut microbial influences in defining the hepatotoxicity of tacrine and hence provides critical insights for personalised medicine initiatives. The findings were reported in *Hepatology* (November 2017).

Combating drug-resistant bacteria

A multidisciplinary research team led by Prof Eric CHAN employed an integrated strategy combining pharmacokinetics, toxicology, metabolomics, genomics and metagenomics to interrogate the role of the liver-gut microbiota axis in underpinning the hepatotoxicity of tacrine in Lister-hooded rats. Their study established the pertinent gut microbial influences in defining the hepatotoxicity of tacrine and hence provides critical insights for personalised medicine initiatives. The findings were reported in *Hepatology* (November 2017).

STUDENT ACHIEVEMENTS

A video on communication for an Interprofessional Education activity by our students Tricia TAN Shi Ying, TAN Si Wen, Cheryl TAN Wei Lin and TAN Wei Qin, and nursing students Angie LOH An Qi and PHEE Soon Min was chosen as a winning presentation at the Centre for the Advancement of Interprofessional Education (CAIPE) Annual General Meeting on 15 June in London.

Donavan Marcus NEO (top right), a Year 4 student, was one of the winners of the annual university-wide Outstanding Undergraduate Researcher Prize. His project focuses on the development of therapeutic drugs to treat Chikungunya fever (see pg 15).

OTHER SIGNIFICANT INITIATIVES

An international conference on ‘Scientific Frontiers in Natural Product Based Drugs’ was held at NUS on 6 and 7 July. It was co-organised by the Department of Pharmacy and the Department of Pharmacology, Yong Loo Lin School of Medicine. The conference reports cutting-edge research in the areas of natural products isolation and identification, natural products as bioactive compounds as well as the development of natural products as drugs. It attracted scientists locally as well as from the United States, Australia, Europe and Asia.

Research fellow Dr CHAE Jung-Woo received a Young Investigator Award from the Multinational Association of Supportive Care in Cancer in Washington, DC on 23 June.
EXECUTIVE SUMMARY

The Department of Physics promotes excellence in a range of research areas, including condensed matter physics, surface physics, materials science, quantum physics, quantum information and technology, high energy physics, atomic physics, solid-state ionics, astrophysics, infrared spectroscopy, biophysics, laser optics, X-ray fluorescence, ion beam applications, optics, acoustics, and computer modelling and simulations. Faculty members made several research breakthroughs and served as editors or members of editorial boards of top scientific journals. The department was also the lead organiser for the 30th International Young Physicists’ Tournament (see pg 6).

EDUCATIONAL MILESTONES

Astrophysics, which explains objects and events observed in the sky, is offered as a specialisation under the Physics Major programme. Astrophysics I, a new module launched in 2017, covers astronomical observations and telescopes, as well as celestial mechanics, or the application of classical mechanics to astronomy. The third part of the module introduces stellar physics.

Another new module, Radiation: Scientific Understanding and Public Perception, equips students to evaluate the potential risks and uses of radiation in modern society, including radiation use in medical diagnoses and treatments, and other applications.

RESEARCH COMMENTARIES

Steady-state density functional theory
A team led by Prof ZHANG Chun developed a more general version of the popular and widely-used density functional theory (DFT) which can be applied to steady-state non-equilibrium quantum systems. They introduced an additional degree of freedom, known as the non-equilibrium electron density, into first-principles modelling, known as the steady-state DFT (SS-DFT). SS-DFT provides a reliable theoretical tool for understanding and for the future design of novel nanoscale devices with enhanced functionality.

A new spin on graphene electronics
Graphene is suited for next generation electronics, due to its unique properties including high electron mobility, mechanical strength, flexibility and high thermal conductivity. However, the large electrical resistance at the metal-graphene interface limits the performance of these devices. Prof QUEK Su Ying collaborated with Prof John THONG from NUS’ Department of Electrical and Computer Engineering to show that ‘edge-contacted’ device geometries in Ni-graphene (or Co-graphene) interfaces resulted in some of the lowest contact resistances reported to date. This work has the potential to enhance high performance devices.
Black holes with unusual horizons

Prof Edward TEO and Dr CHEN Yu recently found a new type of black hole whose event horizon is infinite in extent yet has a finite area. Resembling bottles, these black holes are named ‘black bottles’. Black bottles do not exist in normal space, but in a space with a negative cosmological constant known as anti-de Sitter space. Aside from their mathematical interest, black bottles have potential applications to real-world systems such as heavy-ion collisions and high-temperature superconductors, via the anti-de Sitter/conformal field theory correspondence.

STUDENT ACHIEVEMENTS

Valedictorian WONG Zi Heng received an Honours (Distinction) with a Minor in Nanoscience, overcoming tremendous adversity. Zi Heng suffered a life-threatening diving accident in Year 1 that left him paralysed. He returned to school after a year’s absence, where he took on the role of Science Bash Director. At the College of Alice and Peter Tan, he engaged different communities like migrant workers. He also went on an immersion trip to Germany. Zi Heng will work at the Ministry of Education, fulfilling his aspirations to be a teacher (see pg 16).

AWARDS AND ACCOLADES

Prof Bernard TAN was conferred Emeritus Professorship for his leadership and achievements in research, education and service (see pg 36). Prof GONG Jiangbin received the NRF Investigatorship Award (2017) and the World Scientific Award (2017) conferred by the Institute of Physics Singapore (IPS). Prof Utkur MIRSAIDOV and Prof QUEK Su Ying received the IPS Nanotechnology Award (2017). Prof LIN Hsin was named in the Highly Cited Researchers (2017) report.

KEY EVENTS

Singapore hosted the 30th International Young Physicists’ Tournament (IYPT) for the first time, from 5 to 12 July. IYPT is one of the world’s foremost annual physics competitions. A total of 31 international teams comprising 290 young physicists, jurors and observers took part, marking the highest participation in IYPT’s history. Team Singapore, comprising students from NUS High School of Mathematics and Science and Raffles Institution, emerged the champion (see pg 6).
EXECUTIVE SUMMARY

The Department of Statistics and Applied Probability continued to contribute to impactful research in high-dimensional statistics, computational statistics, statistical inference of complicated data and machine learning. We also made key changes to the undergraduate curriculum to better prepare students for an increasingly data-driven economy. We expanded the scope of data-mining modules and provided students the option of a new Cooperative Education Programme. In 2017, NUS was placed 8th in the world and top in Asia, in the Quacquarelli Symonds (QS) World University Rankings for Statistics and Operational Research.

EDUCATIONAL MILESTONES

We sought to expand the exposure of students specialising in data science through a Data Mining module at the third level, in addition to the current one at the Honours level. This prepares students for careers managing large and complex datasets, which are now generated on a daily basis by activities in the sciences, administration, leisure and commerce.

Data Science and Analytics undergraduates will have the option to participate in the new NUS Cooperative Education Programme that integrates academic studies with on-the-job learning through credit-bearing internships. Students will spend the special term of their second year and their whole third year working in a company. The complexity of their work assignments will increase progressively over the 18-month internship programme, culminating in Honours projects in the first half of their fourth year. Students will acquire valuable industry experience for a career headstart (see pg 5).

RESEARCH COMMENTARIES

Modelling real-life problems with monotone density ratio conditions

The monotone density ratio is a powerful statistical tool for combining multiple medical tests, or biomarkers, for diagnostic purposes. Prof YU Tao, with his collaborators, developed a smoothed likelihood method that estimates the monotone density ratio accurately. These statistical methods can be applied in many research areas, in economics, finance, medical and genetic research. Parts of this work were published in top journals like the *Journal of the American Statistical Association* (August 2016) and *Biometrika* (February 2017).

Better prediction of physical phenomena

Dynamical systems are mathematical objects used to model physical phenomena whose current state varies over time, for example, the swinging of a clock pendulum or the growth of crystals. Prof Alexandre THIERY, with his collaborators in the United Kingdom and Canada, shed light on a new pseudo-marginal approach to better understand the properties of dynamical systems and provide more accurate predictions of related physical phenomena. Parts of his work were published in top journals like the *Journal of Machine Learning Research* (March 2016) and *Biometrika* (September 2017).
**Fast algorithms for quantifying uncertainty**

To understand variability in experiments and observational studies, statisticians construct Bayesian models with parameters estimated from observed data. However, the estimations associated with the Bayesian model are well-known to be computationally expensive or even intractable in very complex models. Prof David NOTT and Prof Linda TAN have made important advances in the variational Bayesian method that provide fast analytical approximations in such complex models. This work has the potential for use in a wide range of applications where large datasets are collected. Their works were published in the *Electronic Journal of Statistics* (March 2016), and *Statistics and Computing* (February 2017).

**STUDENT ACHIEVEMENTS**

Various workshops and competitions provided our students the opportunity to integrate classroom learning with real-life problems. A team of Ph.D. students, WEN Jun, HANG Weiqiang, and YING Baolong, together with Ph.D. student LIU Weizhi from the Faculty of Engineering, clinched second place amongst 50 teams in the first NUS Quant Challenge, where teams built mathematical models to predict the future movements of securities and financial instruments (see pgs 7 and 19).

**KEY EVENTS**

The NUS Statistics Society organised a data analysis workshop on 18 and 19 March for Statistics, Applied Mathematics and Computing Science undergraduates to gain knowledge and acquire skills in data analysis as well as to network with industry experts. Dr Timothy BANKS from market intelligence company Nielsen gave a lecture on ‘How to Find a Planet’. A total of 41 teams also participated in a data analysis competition, where they used programming software to construct models on how different parameters affect the light reflux of a star.
EXECUTIVE SUMMARY

The Lee Kong Chian Natural History Museum (LKCNHM) maintains a world-class regional research collection, conducts biodiversity research and education, and reaches out to the public through various programmes. A new temporary gallery exhibition was unveiled, attracting some 15,000 visitors since its opening. We also organised Fun Rocks@LKCNHM on 11 November, a fundraising carnival which raised over $700,000 for the NUS Science Merit Scholarships (see pgs 6 and 40).

RESEARCH

We survey many habitats in support of Singapore’s efforts to conserve its biodiversity. To date, 140 species of molluscs, over 70 fish and more than 30 crustacean species have been identified in our seas, including new records, and rare and new forms. From our insect-centric Biodiversity Discovery Project, 1,981 ichneumon wasps, 3,292 ants and over 3,000 fly specimens from many families were collected from mangroves and forests. We continued to explore the biodiversity of Southeast Asia, with expeditions planned to Christmas Island, Malaysia and Indonesia. Research staff published 51 peer-refereed papers, mostly in the Web of Science, and 48 other publications.

Our collections continue to attract visiting scientists. In the first six months, 96 scientists from 24 countries used the collections to further their research. The international value is substantial, with 46 loans sent to 38 organisations from 16 countries. We also received many important donations, such as a 5.3m long taxidermised estuarine crocodile from Wildlife Reserves Singapore.

To reidentify these species in the future, new morphological and molecular identification tools (‘DNA barcodes’) are being developed. Many species have been imaged and are now online on the ‘Biodiversity of Singapore’ portal. It features over 6,600 species with links to scientific literature that elaborate on their biology and a ‘virtual repatriation’ section on Singapore specimens now kept in Natural History Museums in the United Kingdom.

OUTREACH

We launched our first temporary gallery exhibition, ‘Out of the Water’, on 11 March. Guests included donors of the Jubilee Whale Fund and those who aided in the salvage process. The book, ‘A Whale Out of Water’, capturing the museum’s epic journey to secure and display the Jubilee Whale, was also unveiled.

Over 600 members of the public learnt about marine biodiversity at our Marine Open House on 18 March, held in collaboration with the St John’s Island National Marine Laboratory. We also conducted over 400 programmes for 8,000 participants from 68 schools.
Our faculty members are widely recognised by their peers for their research achievements and enjoy high international standing. Our reputation for excellence was reinforced with various prestigious awards for our faculty members’ exceptional contributions to science and research.

Recognising Excellence

ASEAN BIODIVERSITY HEROES AWARD AND NUS OUTSTANDING SERVICE AWARD 2017
Prof Leo TAN, Lee Kong Chian Natural History Museum, was one of 10 people who were named Asean Biodiversity Heroes for his significant contributions to biodiversity conservation, education, and advocacy efforts in Singapore. This year, he also received the NUS Outstanding Service Award for transforming teacher and science education in Singapore as well as nurturing engagement in science among the public (see pg 23).

FELLOW OF THE AMERICAN MATHEMATICAL SOCIETY
Prof SHEN Zuowei, Department of Mathematics, was elected as a Fellow of the American Mathematical Society, for his contributions to approximation theory, wavelet theory and image processing. The Fellows of the American Mathematical Society programme recognises members who have made outstanding contributions to the creation, exposition, advancement, communication and utilisation of mathematics (see pg 27).

2017 INFORMS OPTIMISATION SOCIETY FARKAS PRIZE
Prof TOH Kim Chuan, Department of Mathematics, and Institute of Operations Research and Analytics, was awarded the 2017 Farkas Prize by the INFORMS Optimisation Society for his fundamental contributions to the theory, practice and application of convex optimisation, especially semidefinite programming and conic programming. Each of his contributions is an impressive mixture of new theoretical insights, numerically sound algorithmic strategies and efficient implementation (see pg 27).
STAYING AHEAD of the Future

PROVOST’S CHAIR PROFESSORSHIP
Prof DINH Tien Cuong, Department of Mathematics, was appointed Provost’s Chair Professor. He is considered one of the world’s top analysts working on ‘complex dynamics of several variables’ (see pg 27).

NUS OUTSTANDING RESEARCHER AWARD 2017
Prof LIU Xiaogang, Department of Chemistry, was awarded the NUS Outstanding Researcher Award. He has done groundbreaking research on using luminescent nanocrystals to monitor chemical reactions, with applications in sensing and biomedicine (see pg 25).

NUS OUTSTANDING EDUCATOR AWARD 2017
Dr Adrian Michael LEE is one of the pioneers in NUS in technology-enhanced education. He is well-recognised for his effective use of technology to enhance learning and his successful implementation of the flipped classroom pedagogy. In his blended learning sessions, he uses an array of technological tools to raise the level of interaction with students (see pg 25).

EMERITUS PROFESSORSHIP
Prof Bernard TAN, Department of Physics, was conferred Emeritus Professorship for contributing to many key developments in science and beyond, in Singapore. His achievements in research, education and service are significant, without which many of these developments would not have happened, or would have taken a longer time to come forth (see pg 31).
Some of our alumni have ventured into the unknown by starting their own businesses. Through hard work and determination, they overcame challenges and translated their dreams into products and services that benefit society. Some have made the leap overseas.

Daring to Dream

Paksong Coffee Company Pte Ltd
Chemistry alumnus Mr Jeremy CHOONG is a coffee entrepreneur based in Laos since 2007. Leveraging on his organic chemistry knowledge to achieve unique coffee flavours, Jeremy gained an edge over more than 20,000 local coffee growers by farming specialty coffee. He continues to improve his coffee quality, and fermentation and processing methods. Paksong Coffee’s extended family farms now produce 220 tonnes per year and its revenue has grown 500% in the last five years.

StratifiCare Pte Ltd
Life Sciences alumnus Dr Anthony CHUA co-founded StratifiCare™ in 2015. The medical technology startup develops technologically advanced in vitro diagnostic solutions to further personalised medicine. This helps physicians make informed care decisions and improve clinical outcomes for patients. Anthony was also actively involved with biotechnology/medical technology startups locally and internationally. StratifiCare™ is among the first local medical technology startups with ISO 13485 certification for product quality.

Spark Systems Pte Ltd
A veteran entrepreneur in the finance industry, Mathematics and Economics alumnus Mr WONG Joo Seng conceptualised and founded Spark Systems in 2016. Joo Seng aspires to build a competitive forex exchange (FX) marketplace to address high transaction fees in current FX platforms. Spark Systems is a fast, resilient and cost-efficient trading platform for institutional traders in Singapore. It received a Monetary Authority of Singapore grant of $11.8 million and went live in July this year with one of Singapore’s largest and most successful hedge funds.

Sun Electric Group Pte Ltd
Physics alumnus Dr Matthew PELOSO founded award-winning Sun Electric, the first fully licensed solar energy technology and retail company in Singapore. It started live distribution of solar power to local businesses in 2016. SolarSpace™, its smart energy distribution system, matches consumers with rooftop owners, enabling anyone to access locally produced solar energy. Sun Electric has been launched in the United States, Australia, Japan and the Philippines. It plans to expand its technology which was testbedded and commercialised here.

FinBook Pte Ltd
Quantitative Finance alumnus Mr Jerry LI, and Quantitative Finance and Statistics alumnus Mr CAO Yizhou co-founded FinBook, a financial technologies startup utilising cloud technologies to provide customisable portfolio management for global investors. Their product covers financial instruments in multiple asset classes and cryptocurrencies, in several markets internationally. The multiplatform product also securely stores investment data on the cloud.
The Faculty organised several new engagement initiatives to strengthen the Science alumni network. Our programmes encourage alumni to stay connected, while providing them meaningful ways to engage our students.

Forging Alumni Bonds

Alumni GO OUT
These are quarterly excursions for alumni to rediscover Singapore’s attractions. On 10 June, alumni toured the St John’s Island National Marine Laboratory and learnt about the island’s history and biodiversity. On 7 October, they enjoyed an exclusive guided tour of the Peranakan Museum.

Industry networking sessions
Various sessions, which included science-focused industries and recruitment agencies, were organised to update alumni on industry developments. More than 150 alumni from diverse industries attended.

The first session on 4 August, held with BLOCK71 Singapore and NUS Enterprise, delved into Singapore’s startup ecosystem. Life Sciences alumni Mr HEW Joon Yeng and Mr Lyon LIM discussed how they created Pigeonhole Live, a question-and-answer tool, which has achieved global impact.

On 14 September, our alumni working at the Agency for Science, Technology and Research (A*STAR) shared on their career journeys there. Over 20 alumni joined the Young Educators in Science sharing and Ministry of Education networking session on 26 October.

Entrepreneurs talk
Some of our alumni who are entrepreneurs shared their experiences with students at a talk organised by the NUS Students’ Science Club on 17 February. Life Sciences’ Mr Shamir RAHIM shared how his company Sypher Labs Pte Ltd revolutionises logistics with cloud technologies. Chemistry’s Mr Joey WANG, who founded Appiloque Pte Ltd, discussed the attributes of successful entrepreneurs.

Single Mingle
This facilitates mingling amongst single alumni through activity-based workshops. A session with interactive games and art jamming on 27 and 28 May drew more than 70 alumni. Another workshop on 2 December introduced alumni to leather crafting.

NUS Alumni Hong Kong Chapter
On 8 June, members celebrated the appointment of alumna Ms CHAN Kailin as the Chapter’s new chairperson. Kailin built AlfaCloud into a leading regional technology firm and was nominated as Nobel Laureate of Young Social Leaders of Hong Kong. The Chapter organises sharing sessions on frontier technologies, charity and sports events, as well as speaker series with top universities.
Making a Mark

Many of our alumni are leaders and game-changers in their respective fields. We feature alumni who are making significant impact in diverse professions and sectors, including healthcare, data science and security.

Mathematics alumnus Mr KOH Hong-Eng is the Chief Public Safety Scientist at Huawei Technologies Co Ltd. His team leverages cloud, Big Data, Internet of Things, Artificial Intelligence etc., to enhance public safety by detecting, responding to, and recovering from threats like terrorism, crime and disaster. This makes cities and countries safer.

Hong-Eng developed the Social-Enabled Policing principle, a community policing initiative for the social networking age, and the Collaborative Public Safety concept to digitally transform public safety through multilevel collaborations.

Chemistry alumna Dr YEH Ka-Lo (right) is a Technology Specialist at Fish & Richardson P.C. (Boston), the United States’ top patent and intellectual property litigation firm. Due to complete her Doctor of Juridical Science in 2019 at Harvard Law School, Ka-Lo has successfully diversified into the niche field of patent prosecution and counselling, specialising in optics, medical devices, nanotechnology and semiconductors. She sits on various committees on intellectual property, the Women’s Leadership Network and Young Lawyers Network.

Life Sciences alumna Dr LI Jingmei (top right) is a Senior Research Scientist at the Genome Institute of Singapore. She studies the individualised prevention of breast cancer, the leading cause of cancer deaths among Singapore women. She aims to discover genetic risk markers that could predict aggressive breast cancers. This could reduce the disease’s incidence and mortality through early preventive and personalised treatments.

Jingmei received the UNESCO-L’Oreal Women in Science International Fellowship (2014), Singapore National Research Foundation Fellowship (2017), and the Singapore National Academy of Science Young Scientist Award (2017).

Physics alumnus Dr GOH Jing Qiang is a Researcher at NEC Laboratories Singapore, which leverages on Artificial Intelligence and advanced information communication technologies to co-create social solutions with governments, enterprises and research institutes in domains like public safety, healthcare etc. Jing Qiang applies machine learning and optimisation techniques to develop public transportation planning solutions in Singapore. His work aims to shorten bus operators’ planning time and optimise bus schedules in real-time, thereby improving commuters’ travel experience.

Statistics alumnus Mr WANG Weimin is a Data Scientist at a unicorn startup, Indonesian ride-hailing firm Go-Jek. Weimin applies data analytics and Artificial Intelligence to create smart systems that determine surge pricing, recommend restaurants to customers, and gain consumer behaviour insights. Go-Jek, Indonesia’s first billion dollar startup, is expanding its ride-hailing services in Southeast Asia. It is also venturing into concierge services, and food and grocery deliveries in Indonesia.
Realising Dreams

The Faculty embarked on a strategic initiative, launched at a dinner in April, graced by then President Dr Tony TAN, to raise 100 NUS Science Merit Scholarships (see pg 6). We held a fundraising carnival at the Lee Kong Chian Natural History Museum on 11 November, which raised over $700,000. The Guest-of-Honour was Mr ONG Ye Kung, Minister for Education (Higher Education and Skills) and Second Minister for Defence (see pgs 6 and 34).

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In September, Mdm LEE YING gifted $400,000 to the Department of Pharmacy to fund research on the efficacy and safety of medicinal plants and their components, to address healthcare and medical needs. The research project will be led by Prof KOH Hwee Ling and her team.

Marcus WONG, Year 3 Pharmacy, the first recipient of the Leong Mun Sum Scholarship, said, “I am motivated to strive even harder in and out of school.” He added, “It was a privilege to meet Mr LEONG Mun Sum. He has great vision, and his insights fuelled my interest in entrepreneurship.”

I went on a Student Exchange Programme at Amsterdam University College. It was my first trip to Europe and I was fortunate to be able to experience life in the Netherlands.

KHOO Yi Wei, Year 4 Life Sciences
Alice and Peter Tan Academic Award recipient

The Science Student Overseas Exposure Fund was set up in 2006 to enable financially disadvantaged students to participate in overseas programmes.

The Science Student Fund was established in 2008 to enable financially needy students to enjoy the full benefits of NUS Science’s education without financial worries. We are grateful for the ongoing support of our benefactors. In July, QAF Limited pledged a gift of $100,000 in the name of Gardenia Foods (S) Pte Ltd to set up the Gardenia Bursary for our students over five years. The bursaries are valued at $10,000 each.

The bursary lightened my financial burden, allowing me to focus on education as a stepping stone to a better future. It also inspires me to help the less fortunate.

SEE Jian Wei, Year 1 Food Science and Technology
Gardenia Bursary recipient

I lost contact with my parents and siblings and I receive no support from my family. I am grateful for the bursary which covers my tuition fees. I would not be able to make it without the support.

LIM Chung Hoe, Year 3 Physics
Alice and Peter Tan Bursary recipient

Please contact Ms YONG Lai Cheng at sciylc@nus.edu.sg if you have queries or wish to make a donation.
Building Research Capabilities

This chart shows the funding sources for research grants which our researchers have won over the past five years. As research projects typically run for three to five years, the research grant income from FY2012 to FY2016 gives a snapshot of the research intensity at the Faculty. While the public sector grant agencies together remain as the largest grantor for our research programmes, the Faculty has been developing funded partnerships with companies and statutory boards. These will increase the impact of our research work on industry and society.

$325 million
IN RESEARCH INCOME

Note:
* Public (Open) includes the Ministry of Education, National Research Foundation Singapore and Agency for Science, Technology and Research open grant calls administered by the Government of Singapore.
* Industry includes funding from licensing agreements.
* Percentages of allocation may not add up to 100% due to rounding errors.
Undergraduate students: 5126
Undergraduate programmes: 34
Minor programmes: 16
French double degree programmes: 7
Concurrent degree programmes: 4

Postgraduate students: 1351
M.Sc./Pharm.D. programmes: 18
Ph.D. programmes: 6
Joint Ph.D. programmes: 5
Joint M.Sc. programmes: 2

The figures are updated based on Academic Year 2016/2017.
**Research Output and Recognition**

**ASIA FIRST^**
- Chemistry
- Environmental Sciences
- Mathematics
- Statistics & Operational Research

**GLOBAL TOP TWENTY^**
- Biological Sciences
- Chemistry
- Environmental Sciences
- Mathematics
- Materials Science#
- Pharmacy & Pharmacology
- Statistics & Operational Research

^ Research subject ranking
Source: QS World University Rankings by Subject 2017
# Includes contributions from materials physics and materials chemistry

1254
Research articles published
(Source: Web of Science)

68115
Citations received
(Source: Web of Science)

28
New patent families filed

32
Research collaborations with industry

12
Research collaborations with statutory boards

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**Graduating Class of 2017**

**Graduate Coursework Programmes**

- M.Sc. [Physics]: 4 graduates
- M.Sc. [Applied Physics]: 7 graduates
- M.Sc. [Mathematics]: 14 graduates
- M.Sc. [Chemistry]: 35 graduates
- M.Sc. [Statistics]: 79 graduates
- M.Sc. [Pharmaceutical Sciences and Technology]: 6 graduates
- M.Sc. [Science Communication]: 11 graduates
- M.Sc. [Industrial Chemistry]: 15 graduates
- M.Sc. [Quantitative Finance]: 53 graduates
- Doctor of Pharmacy: 7 graduates

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**Graduate Research Programmes**

- M.Sc.:
  - Statistics and Applied Probability: 6.3 graduates
  - Mathematics: 12.2 graduates
  - Physics: 19.8 graduates
  - Pharmacy: 25.6 graduates
  - Chemistry: 44.8 graduates
  - Biological Sciences: 51.7 graduates

- Ph.D.:
  - Statistics and Applied Probability: 3.7 graduates
  - Mathematics: 7.8 graduates
  - Physics: 10.2 graduates
  - Pharmacy: 18.4 graduates
  - Chemistry: 24.2 graduates
  - Biological Sciences: 29.0 graduates