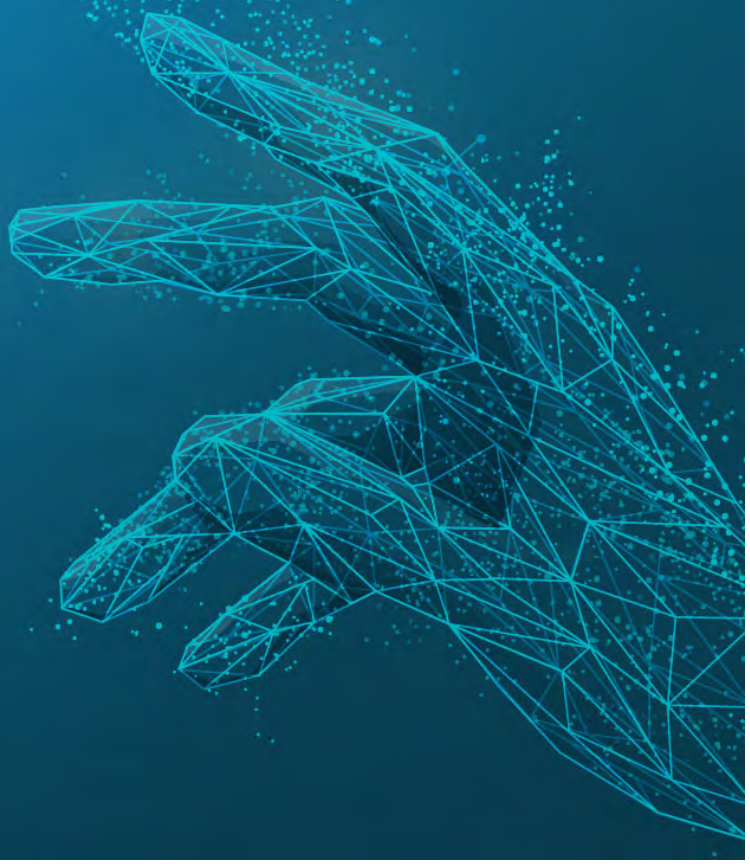
香港城市大學
City University of Hong Kong

UGC Knowledge Transfer Annual Report 2021–22

Knowledge Transfer Beyond Boundaries



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Executive Summary

Recurrent funding for knowledge transfer (KT) has been provided by the University Grants Committee since 2009 to build universities' capability in KT. FY2021-22 was the final year of the Fourth Triennium of the KT funding. Although the COVID-19 pandemic continued to ravage, which inevitably posed a negative impact on our KT activities, in particular, community engagement, City University of Hong Kong (CityU) is pleased to report some exciting KT accomplishments to bring a satisfactory conclusion to the Fourth Triennium.

Firstly, initial success has been recorded for the HK Tech 300™ Programme, which aspires to become the largest university-based entrepreneurship programme in Asia. After only slightly more than one year, we are proud to report an overwhelming response not only from CityU innovators including our students, research staff, and alumni, but also from diverse sectors of the Hong Kong community including major business chambers, start-up incubators and accelerators, venture capitalists, and the general public. The early enthusiastic participation and keen support received have ranged in areas from project assessment to mentorship, professional services, and venture capital funding. Not only have we leveraged the start-up infrastructure of the existing innovation and entrepreneurship ecosystem in Hong Kong, e.g. Hong Kong Science Park's and Cyberport's incubation programmes, CityU has also co-established an innovation and entrepreneurship platform with China Resources Enterprise Limited (CRE), using an initial allocation of HK$ 100 million to nurture our high-potential start-ups into unicorns in the Greater Bay Area. This fruitful partnership combines CRE's diversified enterprise and marketing advantages with CityU's top-notch research strengths. To extend HK Tech 300™'s impact beyond Hong Kong, CityU is planning to expand the Programme to the Greater Bay Area. More details of the Programme's achievements are given in section 1 of the report.

Secondly, with 80 US patents granted in calendar year 2021, CityU has advanced from 51st to 29th in the Top 100 Worldwide Universities Granted US Utility Patents ranking. CityU has been top in Hong Kong for the past six consecutive years, consistently receiving the highest annual number of US utility patents.

Thirdly, for the second year in a row, CityU researchers won the highest number of awards among local institutions at the Inventions Geneva Evaluation Days 2022. They received a total of 22 awards, including a prestigious Gold Medal with Congratulations of the Jury, demonstrating CityU's outstanding translational research and technology transfer achievements, in particular, our vibrant start-ups.

Fourthly, with the addition of the CityU Shenzhen Futian Research Institute, inaugurated in March 2020, CityU now maintains three research institutes, two of which are in the Greater Bay Area, for deepening research collaboration and KT with the Mainland. Together with three other research centres established in collaboration with world-renowned universities under the Innovation and Technology Commission's InnoHK Clusters, these enterprises will definitely add strength and impetus to CityU's research development and will make an impact on Hong Kong and beyond.

Last but not least, impact cases under the five strategic research themes of the University, namely One Health, Matter, Digital Society, Smart City, and Brain, are presented in section 6 of the report, demonstrating CityU's dedication to bringing real benefits to society by putting our research results to practical use in the community at large.

1. Innovation and Entrepreneurship Ecosystem

To support Hong Kong's development into an innovation and technology hub, City University of Hong Kong (CityU) launched a university entrepreneurship programme, HK Tech 300™, that comprises entrepreneurial training, incubation, and capital investment. This Programme, the first of its kind among local universities in terms of scale, aims to establish 300 start-ups within three years. Since its launch in late March 2021, HK Tech 300™ has received an overwhelming response not only from CityU innovators including our students, research staff, and alumni, but also from major business chambers, start-up incubators and accelerators, venture capitalists, and the general community in Hong Kong. The early enthusiastic participation and keen support received have ranged in areas from project assessment to mentorship, professional services such as accounting, and venture capital funding. After only slightly more than one year, HK Tech 300™ has successfully injected momentum into the innovation and technology ecosystem in Hong Kong. To extend its impact beyond Hong Kong, CityU is planning to expand the Programme to the Greater Bay Area. Details of the Programme achievements are given in the ensuing paragraphs.

1.1 Recruiting and Training

The Programme provides four stages of support to members of CityU and the general community in establishing and developing technology start-ups: (1) Recruiting and training, (2) Seeding, (3) Incubating (Angel Fund Investment), and (4) Launching (acceleration) with partners. In terms of training, mass campus recruitment campaigns have been launched that include a series of presentations during Orientation Days, Gateway Education courses, and events in departments and research centres, to facilitate networking and team formation.

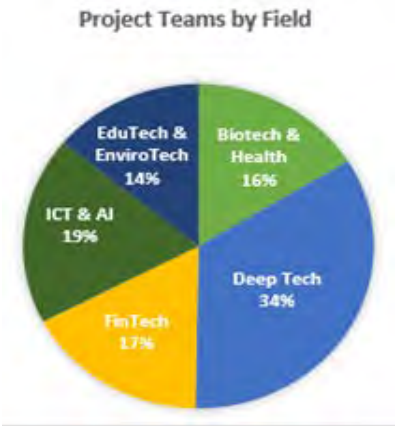
Entrepreneurship training to potential start-up teams is packaged into an eight-week programme that is delivered by two venture capital and acceleration firms. The training programme covers a range of skills essential to kick-start an entrepreneurial journey, develop a business plan, and deliver a pitch. As of June 2022, participants of over 1,000 students, alumni, and general public were attracted to join the HK Tech 300™ training programme.

1.2 Funding

The HK Tech 300™ Seed Fund transforms innovative ideas into start-ups. Of the 600 applications received up to 30 June 2022, from undergraduate and postgraduate students, alumni, research staff and the general public using CityU's intellectual property (IP), over 360 applications covering areas in Biotech and Health, Fintech, Deep Tech, EduTech, EnviroTech, Information and

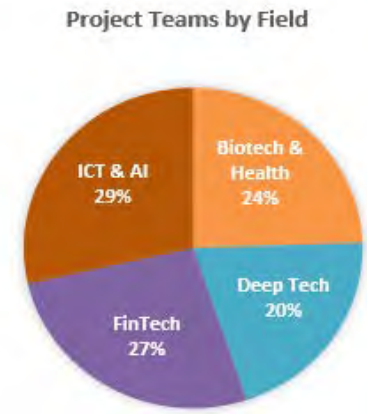
Communications Technology, and Artificial Intelligence were awarded with seed funding of HK$100,000 each.

Teams Awarded Seed Fund in Terms of Field



The HK Tech 300™ Angel Fund is an investment fund that supports early-stage start-up efforts to develop a minimum viable product/service and business model validation. As of June 2022, over 70 start-ups have been approved to receive Angel Fund investment of up to HK$ 1 million each, after stringent assessment by the Screening Panels, Investment Sub-committee and Recommendation Committee, and Investment Evaluation Panel of CityU Enterprises Limited (CityUE) and CityUE Board.

Start-ups Awarded Angel Fund in Terms of Field



Further to the above funding schemes, the Technology Start-up Support Scheme for Universities (TSSSU) continues to offer funding support to CityU start-ups seamlessly at different stages of their life cycle. For the 2022-23 round of application, 13 start-ups were approved to receive a total funding of HK$ 8 million.

1.3 Co-working Space

With the University's support, co-working space is made available for the start-up teams on CityU's main campus and 8/F of United Centre at Admiralty, amounting to a total area of ~2,000 m^2. The co-working space in Admiralty has been in use since mid-November 2021, providing off-campus office space for the start-up teams while also serving as a hub of various kinds of activities including meetings with potential investors, collaborative meetings, investment and incubation events, and workshops.

1.4 Mentorship Scheme

The HK Tech 300™ Mentorship Scheme aims to facilitate sharing of knowledge, expertise, skills, insights and experiences through interaction and communication between mentors and mentees. An introductory Mentor-mentee Meet-up session has been arranged for each cohort to connect the mentees with their mentors. So far, more than 100 mentors have been assigned to the teams to provide guidance and advice for one year during their seeding stage. The scheme is continuously expanding to include more mentors who are veteran entrepreneurs and business leaders.

1.5 Co-development Programmes with Partners

The launch of HK Tech 300™ has been enthusiastically welcomed and supported by relevant sectors of society, including but not limited to the following:

- Further to the MoU signed between CityU Enterprises Limited and China Resources Enterprise Limited (CRE) in July 2021, the official agreement to co-establish an innovation and entrepreneurship platform was concluded in October 2021. With an initial allocation of HK$ 100 million, each party has invested HK$ 50 million to establish a joint venture in Hong Kong with the aim of nurturing our high-potential start-ups, particularly in the areas of Life Science and Health, Biomedical Engineering, and Materials Science and Engineering, into unicorns in the Greater Bay Area. The venture leverages CRE's diversified enterprise and marketing advantages as well as CityU's top-notch research strengths.

- An MoU was signed with the Hong Kong Science and Technology Parks Corporation (HKSTP) in November 2021 to launch a collaborative programme to further promote innovation and entrepreneurship in Hong Kong and the Greater Bay Area. As of the reporting date, more than 230 Seed Fund teams have been admitted to HKSTP's pre-incubation programme, which provides each of the teams with funding support of HK$100,000. Together with the HK$100,000 Seed Fund from HK Tech 300™, these awardees have each received a total of HK$200,000 from HKSTP and HK Tech 300™ to kick-start their entrepreneurial journey.

- An MoU was signed with the Hong Kong Applied Science and Technology Research Institute (ASTRI) in April 2022 to further foster collaboration through developing new research projects by integrating research and development capabilities and IP, as well as supporting the development of HK Tech 300™ start-ups.

- The MoUs signed in June 2022 between CityU and three venture capital fund and technology companies, namely Gravity Capital Partners Company Limited, Market Trend Interactive Solution Limited, and Allied Power Technology Venture LPF, will establish a co-investment partnership that will provide an additional angel fund of at least HK$15 million per year to selected start-ups incubated under HK Tech 300™. This joint effort supports start-ups that specifically benefit social and environmental sustainability, thereby promoting the development of innovation and technology in Hong Kong.

1.6 Collaborative Partners

As of June 2022, the Programme has secured a total of 68 partners including the major business chambers, incubators, accelerators, venture capitalists, and industry associations. They provide our start-up teams with a range of services and business opportunities, ultimately benefitting the overall HK Tech 300™ entrepreneurship ecosystem.

1.7 Support from CityU Alumni

The initial success of HK Tech 300™ would not have happened without the staunch support of our enthusiastic and dedicated alumni. While the CityU Eminence Society, an organisation formed by senior alumni who are dedicated to contributing to CityU's development through their resources, networks, and expertise, is already a HK Tech 300™ supporting organisation, alumni from different industries have been actively involved in serving as Seed Fund or Angel Fund selection panelists to help review and shortlist suitable applicants; participating in the mentorship scheme as mentors to nurture the teams; providing professional services and consultations to facilitate the teams' business development.

1.8 Public Engagement and Promotion

To raise public awareness of HK Tech 300™ and promote application of CityU's IP in technology start-ups, a series of promotional activities were organised. Among these included a summer series of sharings by start-up veterans and experts under the New Venture Creation Platform, that fosters ideas generation, collaboration, learning and sharing, and evolving ideas into potential value proposition. A Patent Utility Challenge competition was also organised, that encouraged participants to kick-start ventures by leveraging CityU's existing patents. HK Tech 300™ has received broad media coverage (over 300) on television, radio, print, and online media. Various advertising media channels were used to promote HK Tech 300™, such as MTR billboards, newspaper advertisement, online advertisement, and social media.

1.9 Achievement Highlights of HK Tech 300™ Teams

- Two Seed Fund teams, namely I²Cool and Greater Bay Biotechnology Limited, won in the Hong Kong Chapter of "Maker in China" Innovation and Entrepreneurship Contest, and I²Cool was the first runner-up in the Global Contest of the competition.

- I²Cool became one of the acceleratees under the "CCG Accel – Powered by HKSTP" programme, and its patented iPaint technology was applied on the rooftop of Central Market, a new landmark on Hong Kong Island, to lower the indoor temperature and thereby reduce electricity consumption of the venue's air conditioners. The start-up is planning to penetrate into the China market soon.

- Two Angel Fund teams, Dayta AI Limited and Kamakura Foods Limited, won the Start-up Express 2021, organised by the Hong Kong Trade Development Council.

- Among the winning teams in the Inventions Geneva Evaluation Days 2022, 14 of them are from HK Tech 300™/Technology Start-up Support Scheme for Universities (TSSSU) at CityU.

- HK Tech 300™ start-ups signed letters of intent to explore collaboration with ASTRI in using its patented technologies and IP in their business development. Albacastor Technology Limited, established by CityU alumni, plans to use UVC reflector technology to decompose pollutants in kitchens and public places, and to monitor pollution. AniTech Limited, established by CityU alumni and researchers, plans to develop artificial-intelligence screening models to enhance the success rate of drug development and accelerate the commercialisation process, which can be used by universities and R&D departments of pharmaceutical companies.

Alpha AI Technology Limited plans to use optical inspection technology to detect defects and damage in the automotive and manufacturing process.

1.10 Expansion to the Greater Bay Area (GBA)

HK Tech 300™ is dedicated to growing and flourishing not only in Hong Kong, but also in GBA, the Mainland and beyond, thereby establishing the largest university-based entrepreneurship programme in Asia. Riding on the initial success of HK Tech 300™, the First Nationwide HK Tech 300 Start-up Competition (第一屆 HK Tech 300 創新創業千萬大賽) (tentative name) is being organised in Mainland China to be held in the second half of Year 2022. The competition aims at synergising the niches and resources of Hong Kong and the Mainland so that the practical application of CityU's research results and IP can be further extended.

2. Facilitating Knowledge Transfer and Commercialisation

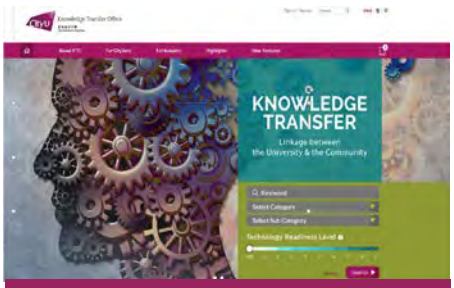
2.1 IP Management

The University has in place a well-established administrative framework and policy protecting the IP generated from research activities. After a stringent vetting process, inventions of high commercialisation value are pursued for patent filing. In the year under review, 220 new patent applications were filed in Hong Kong, the US, Mainland China, and other jurisdictions in various fields of technologies, with 134 patents granted during the same period. By June 2022, CityU's IP portfolio consists of 687 patents granted and a further 558 patents pending.

After years of cultivation, our patenting work is beginning to bear fruit. With 80 US patents granted in calendar year 2021, CityU jumped from 51st to 29th in the Top 100 Worldwide Universities Granted US Utility Patents ranking. CityU has been top in Hong Kong for the past six consecutive years, receiving the highest number of US utility patents annually. The University will make our best effort to sustain this leading position and continue to excel in this area.

2.2 IP Portal

CityU's Knowledge Transfer Office website hosts a list of IPs to broaden marketing channels for licensing. The IP Portal offers Technology Briefs in layperson's terms. Technology readiness level is indicated and drawings/videos are embedded to facilitate understanding of our IPs, in particular, their applications and usage. The IP Portal serves as an effective channel for technology licensing.



Uncover Technologies from this IP Portal

2.3 Outreach

Through the CityU Business and Industrial Club (CUBIC), CityU has forged close ties with senior business executives and industrialists. CUBIC regularly organises events (e.g. Emerging Technologies Forums (ETFs), Technology Transfer Forums (TTFs), and Special Interest Group Gatherings) for its members, and aligns industrialists and academics from the University and other institutions to build a platform to advance technological development and promote cross-institution collaboration. However, owing to the COVID-19 pandemic and social distancing requirements imposed by the Government, CUBIC activities were suspended and we hope they could resume very soon.

Through participating in technology transfer or innovation exhibitions, CityU aims to showcase its latest inventions for commercialisation and expand its client base. Two exhibitions were participated in during the year under review:

- InnoCarnival organised by the Innovation and Technology Commission of the HKSAR Government
- Inventions Geneva Evaluation Days 2022

2.4 Inventions Geneva Evaluation Days 2022


城大揚威日內瓦國際發明展
囊括22獎項 連續兩年為全港大學之冠

For the second year in a row, CityU researchers received the highest number of awards among local institutions at the annual Inventions Geneva Evaluation Days, which in 2022 was a special virtual edition of the renowned International Exhibition of Inventions of Geneva, one of the biggest global events showcasing innovations and inventions. CityU won a total of 22 awards, including a prestigious Gold Medal with Congratulations of the Jury, six Gold Medals, 13 Silver Medals, and two Bronze Medals, demonstrating the University's outstanding research achievements, in particular, our vibrant start-ups. Of the 22 awardees, 14 of them are from the HK Tech 300™ Programme/Technology Start-up Support Scheme for Universities at CityU. A list of the winning projects is given in Appendix 2.

2.5 Promoting Knowledge Transfer beyond Science and Engineering Disciplines

To encourage KT and nurture a KT culture in non-science disciplines, the Excellence in Knowledge Transfer Award has been offered since 2011. The Award gives recognition to faculty members in the College of Liberal Arts and Social Sciences (CLASS) who have made outstanding achievements in applying their knowledge for creating high social impact. The 2021-22 Excellence in Knowledge Transfer Award and Certificate of Merit winners were as follows:

Project Title	Department	Recipient
Excellence in Knowledge Transfer Award		
Group Storytelling Intervention Based on Social Information Processing (SIP) Model to Reduce Reactive and Proactive Aggression in Young Schoolchildren	Department of Social and Behavioural Sciences	Dr. Annis Fung Lai Chu
Certificate of Merit		
Promoting Emotional Resilience to Prevent Parent-child Conflicts among Newly Arrived and Cross-boundary Families	Department of Social and Behavioural Sciences	Dr. Nancy Yu Xiaonan
Risk Perceptions and Social Compliance during the Pandemic: A Cross-national Panel Study	Department of Public Policy	Dr. Edmund Cheng

3. Industry Engagement through Contract and Collaborative Research

3.1 Contract and Collaborative Research

Part of the University's mission is to anticipate and respond to the needs of industry, commerce, and the community by engaging in applied research and using its results to directly benefit Hong Kong and beyond. The University continues to maintain close ties with local and overseas industries and organisations through various forms of collaboration including contract research. Highlights of some contract research projects (including projects from the Government and ITC's Innovation and Technology Fund) in a wide spectrum of disciplines are set out below:

- *Development and Pre-clinical Study of Externally Activated Nanomedicine for Anti-Cancer Therapy*
- *State-of-the-art Health Management for Improved Poultry Production, Product Safety and Quality in Hong Kong*
- *Introduction of Advanced Health Management Tools for Enhanced Pig Production, Product Safety and Quality in Hong Kong*
- *Cholecystokinin Receptor Agonists as Potential New Drugs for Rescuing Learning and Memory Deficiency in Aged Wild Type and Alzheimer's Disease Animals*
- *Transparent Planar Glass Resonator Antenna for Adding 5G Capabilities to Windows*
- *Mobile Application Engine: 5G Network Slice Management Platform*
- *Smart Power Conditioners Using Second Life Electric Vehicle (EV) Batteries*
- *Portable and Low-cost Sensors for the Ambient Air Monitoring of BTEX and Other Volatile Organic Compounds*
- *Turning Water into the Source of Solar Hydrogen via Photocatalyst Panel*
- *Home Learning as a Family-based Programme for Infants and Toddlers in Underprivileged Families*

3.2 InnoHK World-class Research Clusters

CityU has established three research centres under InnoHK, which was spearheaded by the Innovation and Technology Commission, by pooling around 2,000 researchers locally and from all over the world. Thanks to the Government's flagship innovation and technology initiative that aims to promote global research collaboration and put Hong Kong on the global advanced technology map, these three centres will add further strength and impetus to our research development while collaborating with world renowned universities, as follows:

- The Hong Kong Centre for Cerebro-Cardiovascular Health Engineering (COCHE) is a CityU collaboration with the University of Oxford and Karolinska Institutet. The Centre aims to leverage Hong Kong's position as an international city at the heart of China's Greater Bay Area, with ready access to the huge patient pool across the border, and to establish a health technology ecosystem in which a deep talent pool in three world-class universities can tackle cardiovascular diseases at scale.

- The Laboratory for AI-powered Financial Technology (AIFT) is a CityU collaboration with Columbia University. The Centre is a result of the long-term partnership between the two universities

in the areas of data science, mathematics and statistics, computer science, operations research, and social media analytics, and is supported by core research members with a background in the US National Academy of Engineering, Academia Europaea and French Academy of Sciences, and who are fellows of IEEE, SIAM, INFORMS, ASA and the International Communication Association.

- The Centre for Intelligent Multidimensional Data Analysis (CIMDA) is a CityU collaboration with the University of Oxford. The Centre brings together top researchers locally and internationally from multidisciplinary areas, including mathematics, computer science, electrical engineering, and biology, to develop innovative technologies benefiting industry and society. It aims to become one of the world's premier research centres in the areas of data science, engineering, and artificial intelligence.

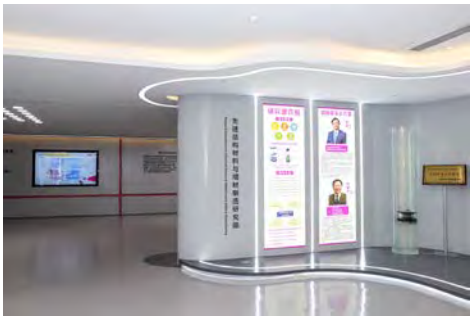
4. Deepening Research Collaboration and KT with the Mainland

4.1 Research Institutes in Mainland China

With the addition of the CityU Shenzhen Futian Research Institute, which was established in March 2020, CityU now maintains three research institutes, two of which are in the Greater Bay Area, for deepening research collaboration and KT with the Mainland.

- **CityU Shenzhen Futian Research Institute**

CityU Shenzhen Futian Research Institute (CityUFRI) is a research institute jointly established by CityU and the People's Government of Futian District, Shenzhen, and was incorporated in the Shenzhen-Hong Kong Science and Technology Innovation Cooperation Zone in March 2020. Relying on the international talent and cutting-edge basic research expertise of CityU, the institute adopts the model of "one institute and two zones" (Hong Kong and Futian) to share the innovation resources of both Shenzhen and Hong Kong.



At present, CityUFRI comprises three research teams, namely the Research Department on Advanced Structural Materials and Additive Manufacturing, Research Department on Key Components of High Temporal and Spatial Resolution Electron Microscope, and Department of Precision Diagnostic and Therapeutic Technology. CityUFRI aims to be at the cutting edge of development in materials science, by establishing and training world-leading innovation teams, focusing on basic research and original results, and building capacity for internationally leading innovation.

- **CityU Shenzhen Research Institute**

Research development in Shenzhen recorded a steady growth in 2021-22. A total of 66 new research projects were initiated via the research platform in Shenzhen: the CityU Shenzhen Research Institute (CityUSRI). These projects included 34 projects funded by the National

Natural Science Foundation of China (NSFC), 18 by the Shenzhen Science, Technology and Innovation Commission (SZSTI), and one by each of the Ministry of Science and Technology of the People's Republic of China (Major Programme) and the Department of Science and Technology of Guangdong Province. CityU topped all the universities in Hong Kong in receiving the highest number of approved project grants from both NSFC and the SZSTI-Basic Research Programme.

- **CityU Chengdu Research Institute**

  The CityU Chengdu Research Institute (CityUCRI) continues to serve as a strategic platform of the University in Mainland China for research and development, incubation and innovation, as well as professional education and training. Research activity at CityUCRI is gaining momentum and 11research projects are ongoing.

5. Impact Cases

As laid down in the Strategic Plan 2020-25 of the University, CityU strives to combine its collective research expertise to develop translational research for solving global challenges under five strategic themes, namely **One Health**, **Matter**, **Digital Society**, **Smart City**, and **Brain**. We are pleased to report in this section notable impact cases in these areas.

5.1 One Health

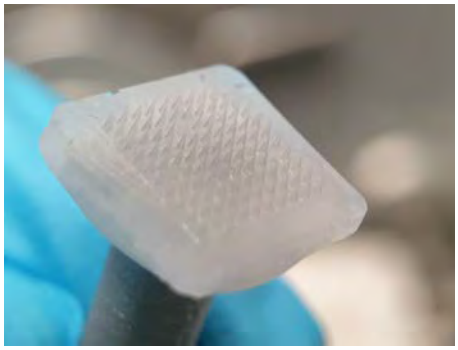
One Health develops and integrates interdisciplinary, problem-based research collaborations and communications in all aspects of health-related issues. CityU excels in this area in diverse aspects, ranging from the invention of a fast-track ventilation system for filtering viruses; to synthesis of the first vaccine against deadly antimicrobial resistant pathogens; development of a new generation of microneedle technology for intradermal delivery of living cells for cell therapy; design of a mathematical model for analysing the relationship between vaccine distribution and the pandemic trend; and people's risk perception, and social attitudes under COVID-19.

It is beyond dispute that the COVID-19 pandemic is one of the largest global challenges in One Health, with a global death toll reaching over 6 million and with no end in sight. Responding to an urgent need for solutions to help medical frontliners to fight the pandemic, Dr. Steven Wang, Assistant Professor in the Department of Mechanical Engineering, invented a low-cost fast-track ventilation system that thoroughly filters viral particles and quickly stops the spread of COVID-19 in the air. The system is equipped with a transparent PVC-plastic hood and high-efficiency particulate air (HEPA) filters that can be placed over hospital beds, thereby protecting healthcare workers by effectively blocking and filtering viruses. Protected by a US patent, the system underwent a clinical trial in February 2022 in the 24-hour Outpatient and Emergency Department (24-hr OED) of Gleneagles Hospital Hong Kong (Gleneagles). The data revealed that the new system can effectively minimise the risk of cross-infection in the emergency room. Subsequently, the system, which provides a negative-pressure environment and is easy to set up, has recently been put into operation in the Gleneagles' 24-hr OED. In addition, Dr. Wang is also collaborating with Gleneagles to install a tiny filtering system for toilet bowls to address the risk of viral exposure, as 5.5 million aerosol droplets, on average, are produced by each toilet flush and viruses may remain in aerosols in a washroom even if the toilet lid is down.

Faculty members from non-biomedical/engineering disciplines also played a role in fighting the pandemic, from different perspectives. One example is a mathematical model developed by Dr. Zhang Qingpeng, Associate Professor in the School of Data Science, in collaboration with researchers from Mainland China. The model analysed how vaccine distribution could affect the pandemic trend. According to data from the UK data platform "Our World in Data", as of February 2022, more than 70% of people in high-income countries had received at least one dose of COVID-19 vaccine, while in low-income countries, the proportion was around 10% only. The CityU research team analysed different scenarios using mathematical modelling and found that infection and mortality rates for COVID-19 in low- and middle-income countries would be significantly reduced if high-income countries donated 46% to 80% of their COVID-19 vaccine stocks to them. Such a donation would also better protect high-income countries in the long term and accelerate the end of COVID-19, as the more uneven the distribution of COVID-19 vaccines, the more serious and frequent outbreaks of COVID-19 would happen.

Another example is a cross-disciplinary research project titled "*Public Health Measures, Risk Perception and Social Attitudes under COVID-19: A Panel Study for Hong Kong*", led by Dr. Edmund Cheng, Associate Professor in the Department of Public Policy. The project examined public health measures, risk perceptions, and social changes in six developed economies in the East and West during the COVID-19 pandemic. More specifically, it attempted to (1) understand how citizens responded to the pandemic; (2) examine their attitudes and behaviours in coping with the crisis, as well as their views and expectations towards governmental actions; and (3) identify the impact of the pandemic on their mental, economic, and social well-being. The impact of this project lies in its longitudinal design and advanced methodologies in offering reliable predictions and remedies to the global crisis, which are particularly important to policymakers.

While the COVID-19 pandemic is among the top global health issues, another public health threat, antibiotic resistance, continues unabated. In this regard, microbiologists and chemists from CityU (Professor Chen Sheng, Associate Dean of the Jockey Club College of Veterinary Medicine and Life Sciences and Professor of Veterinary Bacteriology) and the University of Hong Kong joined efforts to make a breakthrough in synthesising the first vaccine against one of the most deadly antimicrobial-resistant pathogens, the superbug *Acinetobacter baumannii* (*A. baumannii*), which is multi-drug resistant and exhibits extensive resistance to most first-line antibiotics, resulting in a high mortality rate. The vaccine offers an effective alternative for the control of clinical infections caused by *A. baumannii*, for which current treatment options are extremely limited.



Advances in cell therapies have brought promising treatment approaches for previously intractable diseases such as cancers. CityU demonstrated its research strength in this area by developing a new-generation microneedle technology that allows the intradermal delivery of living cells in a minimally invasive manner. Led by Dr. Xu Chenjie, Associate Professor in the Department of Biomedical Engineering, the research team found that vaccination using therapeutic cells through this groundbreaking technology elicited robust immune responses against tumours in mice, paving the way for developing an easy-to-use cell therapy and other therapeutics against cancers and other diseases. The application of this technology is not limited to the delivery of cells. The microneedles can also package, store, and deliver other types of bioactive therapeutic agents, such as proteins, peptides, mRNA, DNA, and vaccines, thereby offering an easy-to-use and effective alternative method for the delivery of therapeutics in clinics. A start-up, receiving investment funding from HK Tech 300™, has been established to commercialise this technology. Currently, this company is developing a convenient, patient-friendly, pain-free, and effective diabetic treatment solution—insulin

cryo-microneedles—to achieve minimally invasive transdermal delivery of insulin.

5.2 Matter

The study of matter (or materials) in its various forms brings together researchers from all the natural sciences in the collaborative development of science, engineering, and technology. One notable impact case in this area is a project titled "*Development of Printable Solar Cells for Transformative Clean Energy and Sustainable Society*", led by Professor Alex Jen and Professor Angus Yip, both from the Department of Materials Science and Engineering, with the aim of addressing energy crisis and global warming issues.

Solar energy is the most abundant renewable energy and will play a critical role in helping achieve carbon neutrality target before 2050. It is predicted that by 2050, 25% of the global energy will be generated by solar electricity, whereas currently it accounts for only ~1% of the global energy supply. Such an enormous scale of energy transformation requires continuous scientific innovation and development of new-generation photovoltaic (PV) technology that is scalable, more efficient, stable, and lower cost. Funded by the Green Technology Fund and ITC's Midstream Research Programme and Guangdong–Hong Kong Technology Cooperation Funding Scheme, with an amount totalling ~HK$15,000,000, the project aims at developing innovative solar technology that can be deployed to overcome the constraints to expanding the solar energy capacity in the city. The team has identified printable organic and perovskite solar cells as the most prominent PV technologies to achieve the goals of this project. More specifically, semi-transparent and colour-tunable PVs will be developed and used as tinted solar windows, façades, or curtains for building-integrated PV (BIPV) applications. To tackle the most critical scientific and technological challenges in printable PV technology, the team has formed a strong collaboration with several world-renowned scientists (e.g. Henry Snaith, Oxford University, and Yang Yang, University of California, Los Angeles) and local/Mainland PV corporations. The success of this project would put Hong Kong in a strategic position to advance cutting-edge research and technology in solar energy, which would have an enormous global impact.

Another impact case is "Super Bamboo™". The mission to reach carbon neutrality by 2050 and other environmental goals mean that there is a strong demand for an innovative high-performance material that is affordable, yet uncompromisingly eco-friendly. Super Bamboo™, is an award-winning material that is three times as strong as normal bamboo. It is even stronger than industrial steel and titanium alloys. Compared with existing bamboo materials, it has superior dimensional stability and is both water-resistant and fire-retardant. Super Bamboo™ uses a breakthrough manufacturing method invented by Professor Lu Yang from the Department of Mechanical Engineering, which involves no formaldehyde, toxic glue, or other toxic chemicals. It could be used in applications such as furnishings, construction, automobiles, and even the space industry in the future. A start-up was established and received investment funding under HK Tech 300™ to commercialise this advanced augmented bamboo material.

5.3 Digital Society

With the advancement of information and communication technologies, digitalisation has permeated our daily lives. Two impact cases are shared under this theme.

Sensing a hug given from a friend through a video call may become a reality soon. A joint-research team consisting of scientists and engineers from CityU (Dr. Yu Xinge and Dr. Xie Zhaoqian in the Department of Biomedical Engineering) and Northwestern University in the United States has developed a skin-integrated virtual reality (VR) system that can be controlled and powered wirelessly. With the meticulous design based on structural mechanics, this pioneering skin-integrated VR device comprises hundreds of functional components, including actuators

simulating touch through millimetre-scale mechanical vibration. These components are integrated into a thin silicone-coated elastomeric layer with a thickness of only 3 mm. It is breathable, reusable, and functional at a full range of bending and twisting motions, and can receive commands wirelessly and simulate "touch" with vibration. The user can feel the touch effect easily after putting a bandage-like thin, soft, and adhesive device onto the skin. This innovation has great application potential in communications, prosthetic control, and rehabilitation. An application trial is under way for users of prostheses to feel the external environment through the sense of touch and receive feedback. It is also believed that the system can greatly enhance the sensory experience in social media interactions, multimedia gaming and entertainment, surgical training, and beyond. Their next research focus will be on the fabrication of an electronic skin that can feel temperature.

The second impact case under the theme of Digital Society is the Centre for Intelligent Multidimensional Data Analysis (CIMDA), which is a member of the AIR@InnoHK Cluster funded under ITC's InnoHK initiative. CIMDA closely works with the University of Oxford on high-calibre projects in mathematics, computer science and engineering, digital media, biology, and medicine. The Centre specialises in diverse fields of artificial intelligence and big data analysis, including:

- Tensor and Hypergraph Theories
- Machine Learning
- Parallel Computing
- Software and Hardware Development
- Signal, Image, and Video Processing and Analysis
- Computer Graphics and Animation
- Biomedical Data Analysis

Key projects include:

- *Efficient Algorithms and Hardware Accelerators for Tensor Decomposition and Their Applications to Multidimensional Data Analysis*
- *Computational Platform for Modelling, Analysis and Prediction of Anti-EGFR Drug Resistance for Lung Cancer*
- *Analysis of Interface Patterns between Biomolecules Based on Alpha Shape Models*
- *Detection of Hyperplanar Co-cluster Patterns in Multidimensional Singular Vector Spaces*

5.4 Smart City

Smart City provides a cross-cutting theme for diverse disciplines and programmes leading to innovative solutions that address regional and global concerns about sustainable energy, climate change, environmental degradation, urban planning, government regulation, and law. Two impact cases reflect CityU's contribution in this area, namely "*Fog-to-electricity Generator with Ultra-high Power Density*", which generates electricity while collecting water from fog, and "*Passive Radiative Cooling Paint*", which provides an energy-saving solution for buildings.

Professor Wang Zuankai and Dr. Steven Wang, both from the Department of Mechanical Engineering, led a research team to develop a fog-to-electricity generator with ultra-high power density. The research team has introduced the first-ever fog-powered green generator for harvesting energy and freshwater from moisture in the air. It combines a newly developed high-power density droplet-based energy generator with a nature-inspired, superhydrophobic fog harvesting mesh. This new technology can produce a record-high power (300 V), with a water collection rate of approximately 250 litres per square meter per day. This dual electricity generator and fog harvester has the highest fog-based energy-conversion efficiency reported to date. It provides a sustainable, stable, low-cost, portable, and eco-friendly power supply solution, while

simultaneously tackling the freshwater crisis in many major cities and areas. Winning a Gold Medal with Congratulations of the Jury in the Inventions Geneva Evaluation Days 2022, the research team is strongly encouraged by this initial success and a start-up receiving investment funding from HK Tech 300™ has been established to transfer the technology to practical application.

"*Passive Radiative Cooling Paint*" is another award-winning project of the University. It received the same distinguished award as the "Fog-to-electricity Generator", but a year earlier. The passive radiative cooling paint, invented by Dr. Edwin Tso, Assistant Professor of School of Energy and Environment, uses an energy-free and refrigerant-free cooling technology that reflects incoming solar irradiance, while emitting thermal radiation to achieve sub-ambient cooling. The technology provides both a sustainable energy-saving and decarbonisation solution to achieve net-zero-energy buildings. A start-up, also receiving investment funding from HK Tech 300™, is commercialising the technology for real-world application. One successful use case is the application of this passive radiative cooling paint, iPaint, on the rooftop of the Central Market, a new landmark on Hong Kong Island, to lower the indoor temperature, thereby reducing electricity consumption of the venue's air conditioners.

5.5 Brain

Brain involves an interdisciplinary joint effort to provide a better understanding of the structure and function of the human brain and the understanding of the mind, including human-machine interfaces. Two impact cases are shared below.

Inborn defensive behaviours, such as the flight, freeze, or fight response, are crucial for animals to survive in a dangerous environment in nature. Neuroscientists from CityU recently revealed the essential neurocircuitry that is fundamental for animals to perceive and integrate environmental cues to initiate defensive behaviour. A research project led by Professor He Jufang, Wong Chun Hong Chair Professor of Translational Neuroscience, and Dr. Chen Xi, Research Assistant Professor in the Department of Neuroscience, showed how the anterior cingulate cortex and auditory cortex within the brain work together to help mice to perceive and integrate environmental cues, such as unusual sounds, airflow, or air puffs, to initiate defensive behaviour when they sense imminent danger. The study was recently published in the scientific journal *Cell Reports*, under the title "*The Anterior Cingulate Cortex Directly Enhances Auditory Cortical Responses in Air-puffing-facilitated Flight Behavior*".

However, every coin has two sides. The research team found that pathological over-excitement of the anterior cingulate cortex may induce an overactive state in the auditory system, which can cause auditory hallucinations. Thus, inhibiting the over-excitement of the anterior cingulate cortex might help minimise auditory hallucinations, providing a new direction for developing treatment for schizophrenia patients suffering from this symptom. More research is required to understand the mechanisms of the anterior cingulate cortex projection to sensory cortices and possible correlations with such pathological conditions.

Another impact case is a start-up, MindAmp Limited, founded by a CityU PhD student in the Department of Biomedical Engineering, which also received investment funding from HK Tech 300™. In response to an emerging market for the application of electroencephalography (EEG) to monitor brain activity by using a sensing device in the ear canals to pick up electric signals generated by the brain, MindAmp specialises in innovative brain-computer interfaces and develops two lines of EEG products. One is a smart meditation system that helps people meditate more easily, and the other is a smart education system that enhances learning efficiency. Other applications related to sleeping and neurological disorders will be developed in the future.

Appendix 1

Summary of Knowledge Transfer Performance Indicators

(Amounts are in Hong Kong dollars)

Performance Indicators	2021-22
***Intellectual Property (IP)**	
No. of patents filed in the year	#220
No. of patents granted in the year	#134
Expenditure involved in generating income from intellectual property rights	$24.5M
IP Licensing	
No. of active licences during the reporting year (inclusive of newly granted ones)	93
Income generated from intellectual property rights	$2.35M
Industry Engagement	
No. of collaborative research projects and income thereby generated (inclusive of ongoing and new projects)	60/$38M
No. of contract research projects (other than those included in "collaborative researches" above), and income thereby generated (inclusive of ongoing and new projects)	247/$125M
No. of consultancies, and income thereby generated	67/$10.7M
Continuing Professional Development (CPD) courses	
Income received from and number of attendees of CPD courses (inclusive of professional doctorate programmes and taught postgraduate programmes except for PCLL)	$923M/11,997
Community Engagement	
No. of public lectures/symposiums/exhibitions and speeches to a community audience organised/co-organised by CityU (seminars and workshops are included)	239
No. of performances and exhibitions of creative works (by staff or students) organised/co-organised by CityU	11
No. of staff engaged as members of external advisory bodies including professional, industry, government, statutory or non-statutory bodies	404
Entrepreneurship	
Number of start-ups/projects (championed by our students/alumni/staff, inclusive of those championed by non-CityU members but using CityU IP) which have received CityU entrepreneurial funding/investment support	308

* inclusive of patents of the Mainland research set-ups.
# figures updated in January 2023 due to a delay in receiving notifications from patent offices.

Appendix 2

List of Winning Projects in Inventions Geneva Evaluation Days 2022

Key Inventors	Invention name	CityU Start-up	Other Awards Obtained
Gold Medal with Congratulations of the Jury			
Professor Wang Zuankai, Dr. Steven Wang	Fog-to-electricity Generator with Ultra-high Power Density	√	√
Gold Medal			
Dr. Tso Chi-yan, Stanley Liu Sai	Intelligent Thermo-responsive Window for Indoor Thermal Management and Energy Saving in Buildings	√	√
Dr. Wang Lidai, Dr. Liu Chao	A Low-cost Multi-contrast Multi-functional Optical-resolution Photoacoustic Microscopy for Early Cancer Diagnostic and Screening	√	√
Dr. Yu Xinge	Touch VR e-Skin for Metaverse		
Dr. Huang Linfeng	Biomanufactured and Customized RNAi Library for Any Species	√	
Prof. Wang Zuankai	Structured Thermal Armor		
Dr. Gajendra Kumar, Dr. Eddie Ma Chi-him	AI-based Pharmaco-electroencephalography (EEG) Platform for Drug Screening	√	√
Silver Medal			
Professor Fu Hongbo	DeepFaceDrawing: Deep Generation of Facial Images from Sketches	√	
Professor Michael Leung Kwok-hi	Nano-Photocatalytic Marine Antifouling/Anticorrosion Paint (Nano-MA2P)	√	
Dr. Xu Chenjie	Cryomicroneedles for Transdermal and Intradermal Cell Delivery	√	√
Professor Hu Jinlian	Super-tough Artificial Spider Silk	√	√
Professor Hu Jinlian	JanusLean Electrospun Nano Fibre Sheet Mask	√	
Dr. Yao Xi	Machine-learning Assisted Discovery of Multifunctional Biopolymer Coating for Pathogen Control	√	

Key Inventors	Invention name	CityU Start-up	Other Awards Obtained
Dr. Vincent Ko Chichiu	Simple Chemical Modification Methods to Develop Oleophilic and Water-repelling Materials		
Dr. Alex Wong Chunyuen	RUNPY: a Rapid, Reliable and Convenient Nitrite Detection Kit for Drinking Water Safety		
Professor Antoni B. Chan	Automatic Wide-area Crowd Surveillance Using Multiple Cameras		
Professor Yan Hong, Fan Xinqi	AI-based Face Mask Detection to Assist in the Control of the COVID-19 Pandemic		
Professor Zhi Chunyi, Chen Ze	Safe Flexible Batteries and Their Applications		
Dr. Lo Wing-Cheong	Smart Wear Enabling the Visually Impaired & the Elderly the Ultimate Freedom to Explore the World	√	√
Dr. Steven Wang	Fast-track Vented Enclosure System for COVID-19 Patient Wards	√	√
Bronze Medal			
Dr. Zhu Kening	Method of Enabling Gesture-based Interaction on the Surface of a Low-cost VR Head-mounted Display		
Dr. Lam Yun-wah	BING: Antibacterial Compound Extracted from Fish Blood	√	