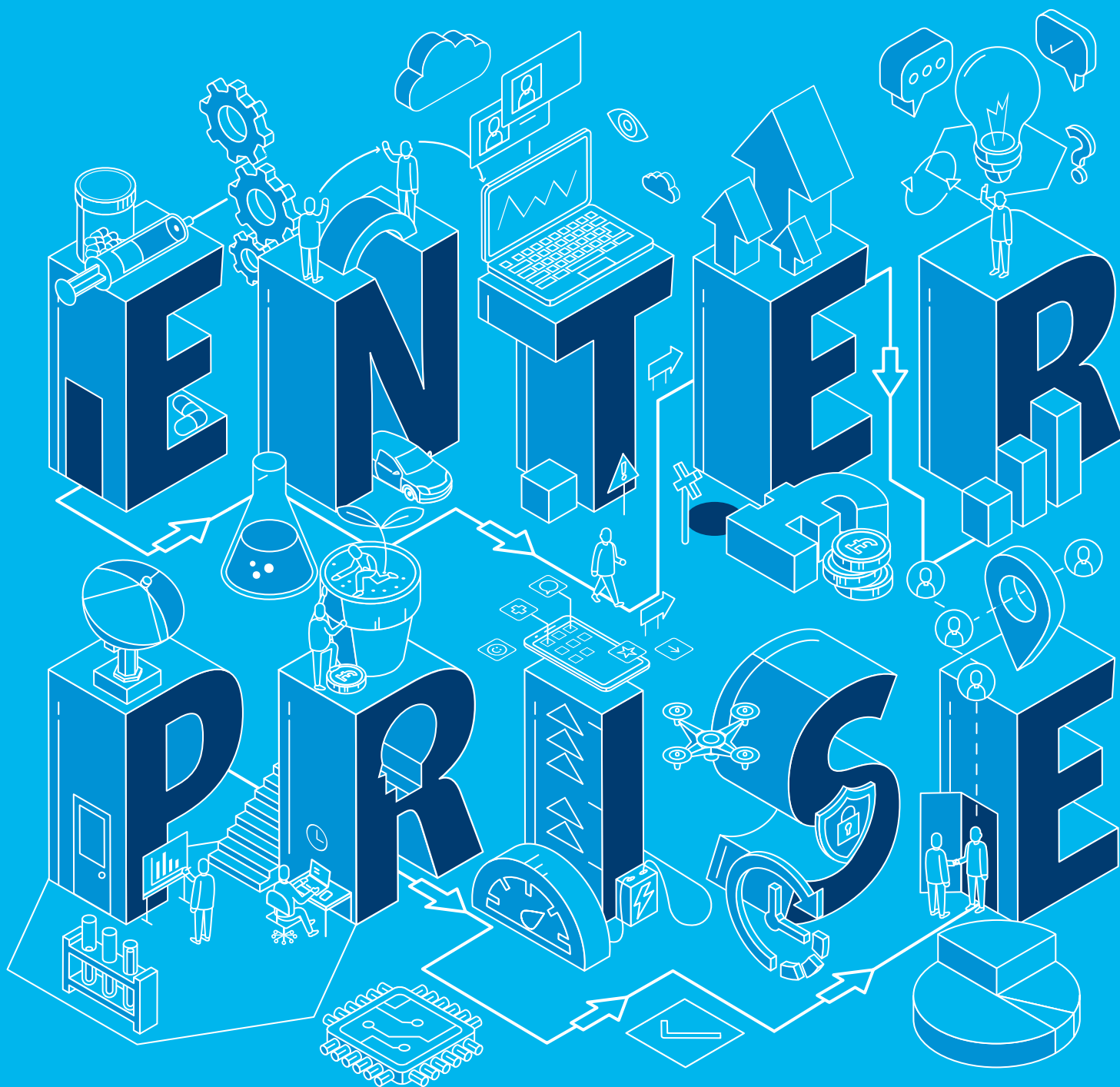


Imperial College
London



Review of
ENTERPRISING ACTIVITY
2018–19

INTRODUCTION

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At Imperial, our mission is not merely to understand the world, but to change it. We are doing this through world-leading research and education, and by exercising our translational and commercial capabilities, and collaborative spirit, to turn great academic thinking into transformative real-world innovations.

Earlier this year, we set out in our Academic Strategy an ambition to help make society healthy, sustainable, smart, and resilient: four themes that capture some of the great scientific and societal challenges of our time.

This ambition is especially resonant when we consider the global response to COVID-19. Imperial teams are working, often with industry collaborators, to develop epidemiological models, an RNA vaccine, point-of-care virus and antibody tests, and a design for an emergency ventilator. They are aiding the digital response to the pandemic by advancing principles to ensure contact-tracing apps preserve privacy. And they are looking at ways to build a more resilient and sustainable economy for the post-pandemic world.

Imperial's rapid response to the pandemic is in many cases the result of research carried out over decades. The epidemiological models devised by Professor Neil Ferguson and colleagues, which influenced decision-making by governments around the world, draw on techniques that were already under development when he advised the UK government on the foot and mouth epidemic in 2001. Professor Robin



Shattock, who leads one of two UK-based teams developing a COVID-19 vaccine, is building on groundwork carried out over a similar period.

This research is now accelerating at an extraordinary rate. With an acute sense of urgency and significant support from government, philanthropists, and industry, we are seeing progress that would normally take years happen in months. To make this rapid impact, some researchers are repurposing existing technologies. Point-of-care tests built using existing platforms have been developed by teams led by Professor Molly Stevens, Dr Firat Güder, Dr Pantelis Georgiou, and Professor Chris Toumazou, the latter with technology from his consumer DNA-testing scaleup DnaNudge.

Some staff and student teams are working on completely new initiatives. A team at our prototyping facility, the Advanced Hackspace, has designed a face visor and has manufactured 38,000 of them for the Imperial College NHS Trust using a floor of our Translation & Innovation Hub that has been converted for the purpose. They are supported by Rolls-Royce Motor Cars, which has provided kits for assembling many of the visors. Another group, led by Dr

Joseph Sherwood, has designed a new kind of emergency ventilator. In contrast to existing designs, the new ventilator can be assembled quickly from off-the-shelf components and the team is working with manufacturers who are ready to mass produce the devices.

The teams have been able to rapidly launch these initiatives thanks to our established cross-disciplinary communities, such as the Hackspace, and a culture of collaboration that allows us to assemble networks of staff, students and outside collaborators on the fly. The can-do ethos, that strong desire to use our expertise to change the world, is something that sets Imperial apart from many other universities. You see it in our culture and the kind of people we attract. We could not make the desired impact without industry partners, and our highly productive relationships with friends and collaborators in industry are also central to our work.

In Imperial's Enterprise Division, 140 specialists in industry partnerships, project management, consultancy, entrepreneurship and commercialisation are helping to make an impact with this work. They have expanded our digital

offering by providing services such as the student entrepreneurship hub online. And they are continuing to use their commercial skills to help turn research into world-changing inventions, and help businesses and investors establish connections with our academics and students.

This edition of the *Review of Enterprising Activity* offers a sample of the work our community is doing to make a real difference through new technologies, ventures, and industry collaborations. It showcases the kind of energy and enterprising endeavour that will change the world and help us tackle the evolving challenges the world faces in the years to come.

We want to work with you on these challenges. If you are inspired by what you read here and would like to explore opportunities to collaborate, I warmly invite you to begin a conversation with our Enterprise team.

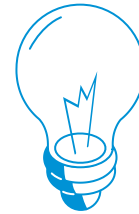
Professor Nick Jennings
Vice-Provost (Research and Enterprise)
Imperial College London



ENTERPRISE METRICS

HIGHLIGHTS, 1 AUGUST 2018 – 31 JULY 2019

233
new inventions



INVENTIONS

980
invention disclosures
portfolio



IP
PROTECTION

153
patents filed

332
patent
portfolio

63
patents
granted

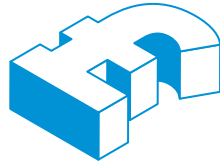
21
new deals



LICENSING

231
licence
portfolio

£5.9 million
IP income



REVENUE
AND
FUNDING

£64.8 million
industry research
funding

62
startups
formed

£21.6 million
funding raised
by IP startups



STARTUPS

72
active IP
startups

19
housed in
incubator

151
active student
startups

£10.1 million
consultancy income



CONSULTANCY

494
companies supported
through consultancy



The founders of Lixea have developed a novel technique to transform waste biomass into plastics, fuels, materials and chemicals.

Photo: Jody Kingzett



Professor Claire Adjiman is working with Eli Lilly and Company to find ways to manufacture medicines more efficiently.



Imperial is using a Toyota Mirai hydrogen fuel cell car to support its work exploring hydrogen as a future source of clean and sustainable energy, acquired with support from the Office for Low Emission Vehicles, Hydrogen Mobility Europe and the Fuel Cells and Hydrogen Joint Undertaking.

Photo: Thomas Angus

SUSTAINABLE SOCIETY

BIOMASS PILOT PLANT

—

Cleantech startup Lixea is building a pilot plant to demonstrate their innovative process to turn waste biomass into plastics, fuels, materials and chemicals, using a €2.3m grant from the European Innovation Council. The company was launched as Chrysalix in 2017 to commercialise research by Dr Agi Brandt-Talbot, Dr Florence Gschwend and Professor Jason Hallett on a novel chemical process using low-cost sustainable solvents. The innovation aims to offer alternatives to the use of crude oil in a variety of applications while forming part of the circular economy.

ENERGY TRANSITION

—

Imperial's partnership with Shell is addressing a variety of challenges in the energy sector, with a focus on working with the company to help it meet its ambition of being a net zero emissions energy business by 2050 or sooner. Across five labs and centres, scientists and engineers are working with Shell to realise new energy storage technologies, reduce methane emissions and develop solutions to decarbonise the mobility sector. They are also advancing digital imaging approaches to better predict fluid flow in a range of scenarios, understanding material behaviour to provide solutions to real-world operational challenges, and collaborating on emerging digital technologies in business.

GREEN TECH CHALLENGE

—

Imperial supported the inaugural Vodafone Future Changers competition, which invited young innovators from across the globe to find solutions to environmental challenges. The 2019 winner, Abdelrahman Fawzy from Egypt, was awarded £5,000 from Vodafone and a package of training and mentoring from the College's Techcelerate programme. Techcelerate aims to help him build a venture that adds value to industrial wastewater generated by textile production. Egypt has low rainfall rates and Mr Fawzy is developing a solar-powered water distillation system that recycles up to 85% of the water put into it.

CLEAN ENERGY CONSULTANCY

—

London's cleantech industry has been given a boost through Imperial Consultants' Innovation Vouchers issued through the Better Futures Programme. Created by the Greater London Authority and Sustainable Ventures, with funding from the European Regional Development Fund, the programme provides startups with access to Imperial's scientific expertise. To date, 17 projects have been undertaken including: advice on battery design and lifetime calculations, new wearable technologies, life cycle analysis, integrating satellite datasets and advice on energy regulation issues.

MEDICINES MANUFACTURING

—

In the latest phase of a longstanding partnership, Imperial researchers led by Professor Claire Adjiman at the Centre for Process Systems Engineering and researchers at UCL are working with pharmaceutical company Eli Lilly and Company to uncover more efficient ways to produce hard-to-manufacture peptide drugs. Combining novel manufacturing techniques, digital tools and artificial intelligence, the researchers aim to ensure that the raw materials are converted into high yields of high purity drugs with little waste. The research is being delivered with financing from Lilly and the UK government through an £11m Prosperity Partnership.

WATER RESEARCH

—

Imperial is collaborating with Anglian Water on research to help the UK water industry meet an ambitious pledge to achieve net zero carbon emissions by 2030, the latest focus of a partnership that began over 20 years ago. Imperial is also working with the company to identify innovative ways of reducing leakage and better understand the environmental risks associated with discharges from combined sewer overflows, among other topics, while Anglian Water is helping train students on the world-renowned MSc in Environmental Technology at the Centre for Environmental Policy.

HEALTHY SOCIETY

JELLY DROPS

Motivated by his grandmother's experience of dehydration, Lewis Hornby created Jelly Drops – hydrating treats that enable people with dementia to hydrate independently. After he teamed up with Claudia Arnold and Nick Hooton, fellow students on the Innovation Design Engineering programme, the venture has gone on to win the Pitch@Palace People's Choice Award and the Imagine IF! Global Accelerator. They were also the first team to partner with Alzheimer's Society through their Innovation Accelerator and have over 50,000 people signed up to their waiting list.

SURGERY TECH

Imperial researchers have developed a novel surgical device that enables large anatomical areas to be clamped during minimally invasive surgery. Laparoscopic (keyhole) surgery often requires folds of tissue to be clamped to stop blood or other fluids flowing and current surgical clips are well designed for tubular structures but not large areas of tissue. Currently in prototype, the Imperial clip and applicator developed by Dr Mikael Sodergren and colleagues features an elongated, stronger clip specially designed to clamp larger areas, improving patient outcomes and surgical performance.

MENTAL HEALTH MED TECH

Academic and student teams from Imperial and seven other London institutions launched technology ventures aimed at improving mental health and wellbeing with support from an Imperial-led accelerator. Researchers behind technologies such as Affect.AI, a machine learning tool that tracks voice changes to monitor depression, BrainBot, a virtual personal trainer for the mind, and Happy Hub, a suite of stress management tools to improve workplace productivity, received funding and training to commercialise their ideas from the MedTech SuperConnector programme.

SURGICAL ROBOTICS

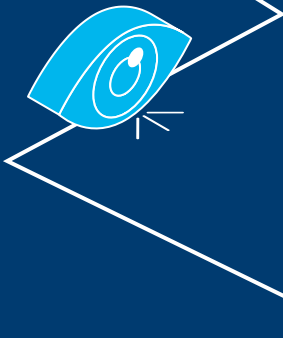
Beginning with a chance conversation over dinner about wood-boring wasps and ending with a four-year project to develop a suite of robotic tools for drug delivery in neurosurgery, the Enhanced Delivery Ecosystem for Neurosurgery (EDEN2020) successfully performed the world's first live flexible needle insertion in July 2019. EDEN2020 is an €8.3 million project funded by the EU's Horizon 2020 programme that aims to use the latest surgical robotic technologies to meet the demand for better and less invasive surgical techniques.

DIAGNOSING SIGHT LOSS

According to the WHO, about 80% of global blindness is avoidable if diagnosed early enough. Student startup VUI Diagnostics is aiming to dramatically speed up the diagnosis of diseases that lead to sight loss with their new retinal imaging tool. They say their device can image ten times more of the eye than standard ophthalmoscopes, allowing for greater accuracy and considerably lower cost. With 90% of the world's blind people living in the developing world, they hope to bring retinal imaging to isolated regions that previously did not have access to equivalent technology.

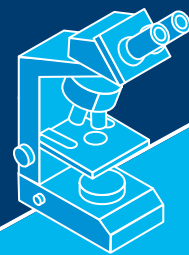
EASY CELL ANALYSIS

Imperial has developed a new device that makes it easy to extract individual proteins, DNA and RNA from cells for research and diagnostic purposes. The tiny syringe-like device, known as a nanotweezer, can be used alongside a microscope to identify cells with interesting features, such as those infected by a virus, and extract molecules directly from the live cells without laborious extraction processes or affecting viability. The technology, developed by Professor Joshua Edel and Dr Alex Ivanov with colleagues in the Department of Chemistry, is currently available for licensing.



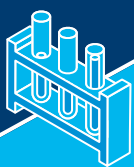
VUI Diagnostics has invented a retinal imaging tool for early detection of eye problems.

Photo: Tom Simpson



EDEN2020 (Horizon 2020 grant 688279) is developing robotic tools for surgery. Pictured here: A device that holds a catheter.

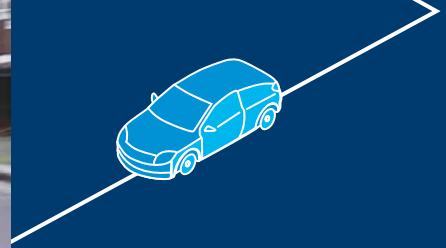
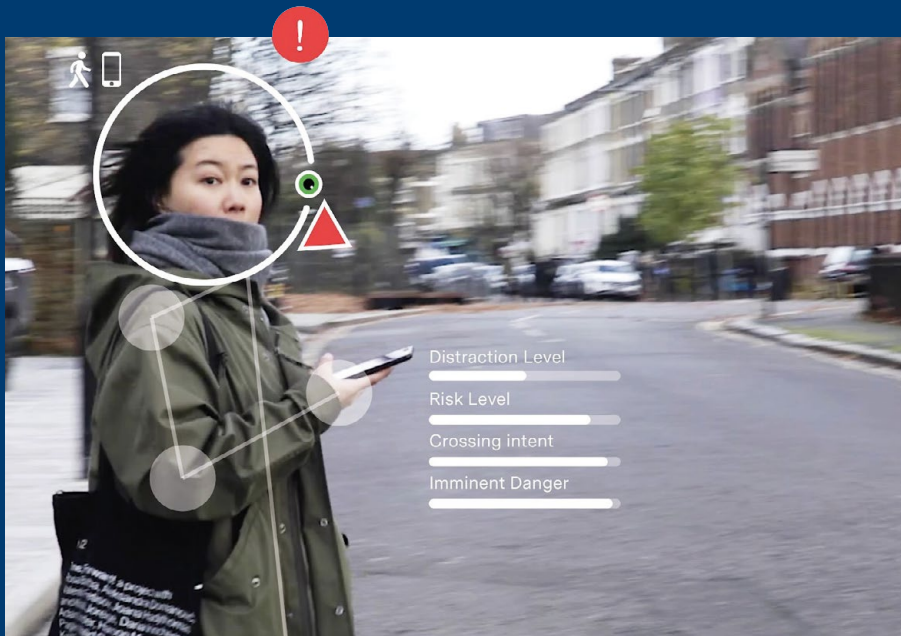
Photo: Joel Trotter



The Jelly Drops team has developed hydrating sweets that allow people with dementia to boost water intake. Pictured from left: Eunice Moon, Lewis Hornby, Nick Hooton, Claudia Arnold.

Photo: Tom Simpson





Humanising Autonomy has created an AI system to make autonomous vehicles safer.

Image: Humanising Autonomy

Dr Declan O'Regan and colleagues are working with Bayer Pharmaceuticals to use machine learning and medical imaging for drug discovery.

Photo: James Tye



DnaNudge offers on-the-spot DNA testing and bespoke nutritional advice based on an individual's genetic profile in its flagship store in London's Covent Garden (pictured).

Photo: DnaNudge

SMART SOCIETY

DNA STARTUP

Startup DnaNudge offers the world's first DNA-based service for healthier food choices. At its flagship store in London's Covent Garden, DnaNudge provides on-the-spot DNA testing, where the customer's genetic profile is mapped to key nutrition-related health traits and paired with app and wearable technology that 'nudges' users towards healthier choices while food shopping. Founded by Professor Chris Toumazou and Dr Maria Karvela, DnaNudge has also developed a solution for rapid, lab-free, high-accuracy COVID-19 testing which is now being deployed within the NHS.

HEART DRUG DISCOVERY

A partnership between Imperial and Bayer Pharmaceuticals is using machine learning to accelerate drug discovery for heart conditions. Machine learning techniques developed under the lead of Dr Declan O'Regan, a consultant radiologist, heart expert Professor Martin Wilkins, and Professor Daniel Rueckert, an expert in computer vision, generate 3D models showing the structure and the function of hearts, and track complex relationships between heart function and genetic data. The results will allow the researchers to discover pathways involved in heart disease that could provide targets for new treatments.

SAFER AUTONOMOUS VEHICLES

Humanising Autonomy, an alumni-founded AI startup building predictive AI technology for urban mobility, has raised investment of over £5.3m. CEO Maya Pindus and her co-founders are piloting an AI system that is able to improve the way vehicles and systems interact with people in any environment by predicting human behaviour. The founders met as students on Imperial and the Royal College of Art's programme in Innovation Design Engineering, and accessed support from Imperial's entrepreneurship training and mentoring programmes to launch the venture.

COMPUTER VISION

Imperial and Dyson are continuing to advance computer vision technology to allow robots to perceive, model, and interact autonomously. The research at Professor Andrew Davison's Dyson Robotics Lab is helping create a next generation capability for robots in unstructured environments. Many other Imperial labs are also developing computer vision technologies, for example a fast and simple method for building a 3D model of a person's face, now available for licensing, developed by Dr Abhijeet Ghosh and colleagues.

ADDITIVE MANUFACTURING

Imperial startup ToffeeAM has secured seed funding and industry customers including General Electric for its design for additive manufacturing software. Founded by Dr Francesco Montomoli from the Department of Aeronautics with researchers Dr Marco Pietropaoli and Dr Audrey Gaymann, the team designed software to create optimised designs for complex 3D-printed parts such as those used in aircraft and car engines. Following three years of lab-based research they launched the company with training and advice from the College.

DATA SPARK

The Data Spark programme, run by Imperial Business Analytics, offers students opportunities to tackle real-world data analytics-based problems by consulting for companies such as DLA Piper and KPMG. With mentoring from Imperial and the companies, recent projects include a dashboard to help global law firm DLA Piper understand how factors such as team structure affect client success metrics, and a simulation to optimise shipping logistics for a client of KPMG's. The companies have benefited from insights that have transformed their practices, and access to a pipeline of talent, with several graduates taking up positions at the firms. Follow at @IB_Analytics.

RESILIENT SOCIETY

FLOW CHEMISTRY

Imperial is partnered with the chemical company BASF to advance flow chemistry, an innovative form of chemical processing in which chemicals are manufactured continuously by pumping reagents through small reactors rather than synthesising them in batches. The technique could allow agrochemical and other chemical industries to improve their R&D workflow, manufacture chemicals more efficiently, and distribute production across smaller plants, creating shorter and more robust supply chains. BASF is working with Imperial on flow chemistry research at two EPSRC Centres for Doctoral Training.

RESILIENT INFRASTRUCTURE

Imperial researchers have developed technologies, available for licensing, to address risks to buildings. A technique developed by Professor Richard Craster can help protect the structural integrity of existing buildings by shielding them from vibrations caused by nearby transport hubs and ground tremors. To mitigate the risk of floods, Dr Alalea Kia, Dr Hong Wong and Professor Chris Cheeseman have developed a new type of high-strength, clogging-resistant permeable pavement. Urban areas are becoming increasingly vulnerable to flooding because impermeable infrastructure does not allow rainfall to drain away naturally. The novel system allows water to drain more effectively, does not suffer from many of the limitations of conventional permeable concrete and is straightforward to install.

ED TECH STARTUP

Following the success of his previous venture, Epigeum, Dr David Lefevre, Director of the Edtech Lab at Imperial College Business School, launched digital learning platform Insendi in 2018, building on experience gained in launching Imperial's online Global MBA programme. Insendi offers an innovative learning experience platform designed specifically for online and blended learning together with expertise in course development, staff training and consultancy, all informed by leading educational research. Now part of Study Group, it is focused initially on business schools, and boasts customers across Europe and Asia.

FINANCE INNOVATION

Imperial researchers are helping banks and other financial services companies innovate in areas like cybersecurity, data analytics, fintech and climate finance. Bank of America is the latest financial institution to benefit from specialist expertise available through Imperial's corporate membership programme, alongside Barclays, HSBC, Mastercard and UBS. HSBC recently published *Lending to Low-Carbon Technologies*, a report on how finance can help meet the UK government's commitment to net zero carbon emissions by 2050 by Dr Charles Donovan and colleagues from the Centre for Climate Finance and Investment. The College is also offering relevant technologies for licensing such as a tool by Dr Yves-Alexandre de Montjoye for assessing the likelihood that an individual can be identified from an anonymous dataset.

URBAN AIR MAP

Imperial experts have created an interactive map (see detail, right) that explores the impact of future technologies and social interventions on urban air quality. Considering not only the particulates we inhale but also the experience of noise, light and smells in our cities, the map illustrates a number of issues and interventions that could emerge in the next 20 years, drawing on the insights of Imperial Tech Foresight and futurist Richard Watson, and the expertise of academics in the Imperial Network of Excellence in Air Quality. The interactive map can be accessed at www.imperialtechforesight.com.

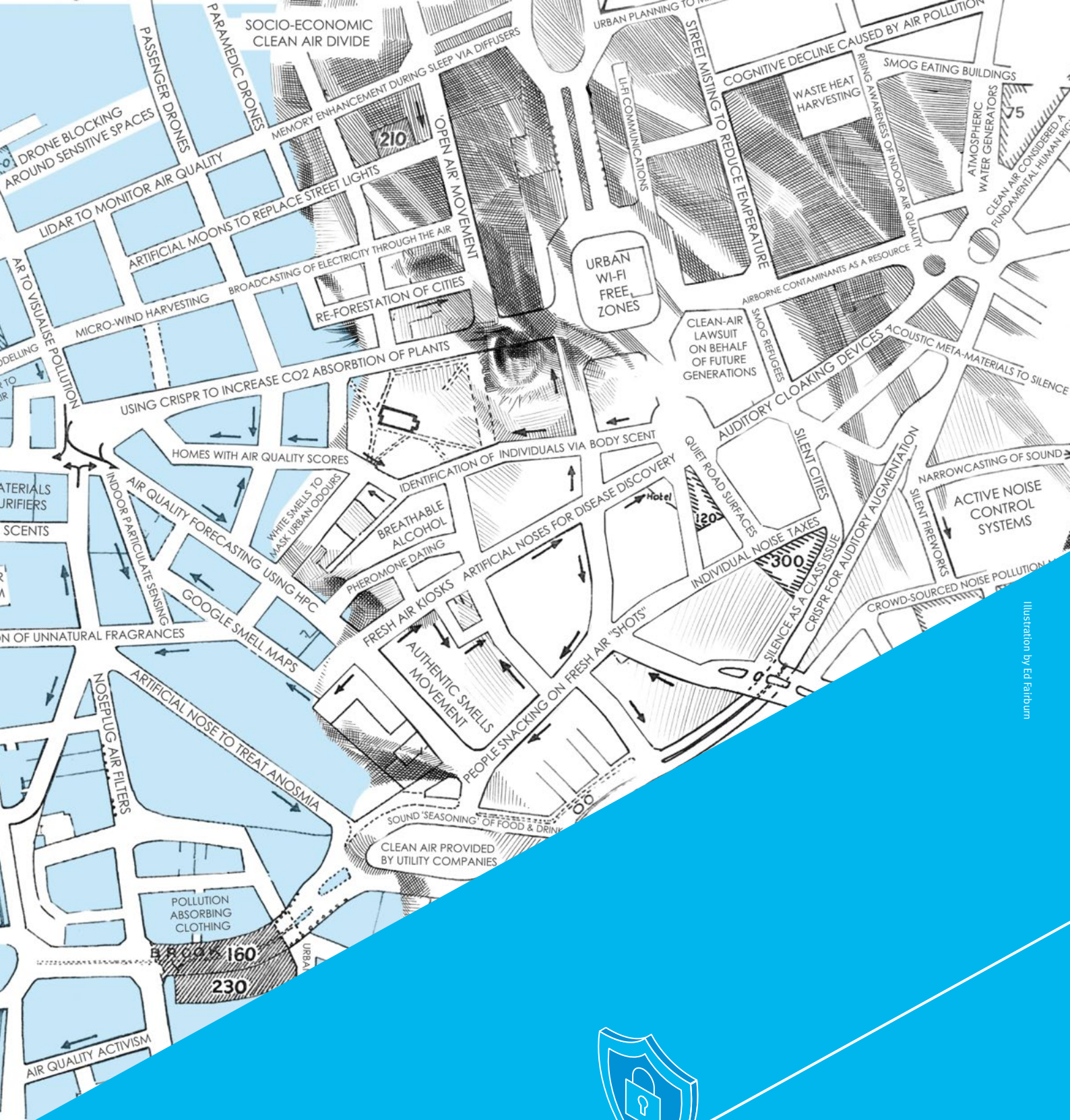


Illustration by Ed Fairburn

OPEN FOR BUSINESS

A WORLD-LEADING ACADEMIC COMMUNITY FIZZING WITH ENTREPRENEURIAL TALENT AND CUTTING-EDGE TECHNOLOGY. THIS IS WHERE SMART BUSINESSES COME TO INNOVATE.

RESEARCH PARTNERSHIPS

Partner with us on impactful research to address your real-world challenges. Our world-leading academic experts and industry partnership professionals work closely with businesses around the world to shape bespoke research collaborations that lead to new technologies and insights tailored to their business needs. Together we can change the world and make your business thrive.

WORLD-LEADING CONSULTANTS

We have nearly 4,000 leading academics at our fingertips, ready to share their expertise in science, engineering, business and medicine. The consultancy services we offer include advisory services, use of specialist equipment, training, testing and analysis for organisations of any size, and our consultancy team is here to help you find the right solutions.



TRANSFORMATIONAL TECHNOLOGY

Our academics invent in a wide range of commercial and industrial fields. You can license our technologies and work with our startups in areas as varied as automotive, energy, electronics, diagnostics, therapeutics, med tech and software.

PROJECTS AND VENTURES

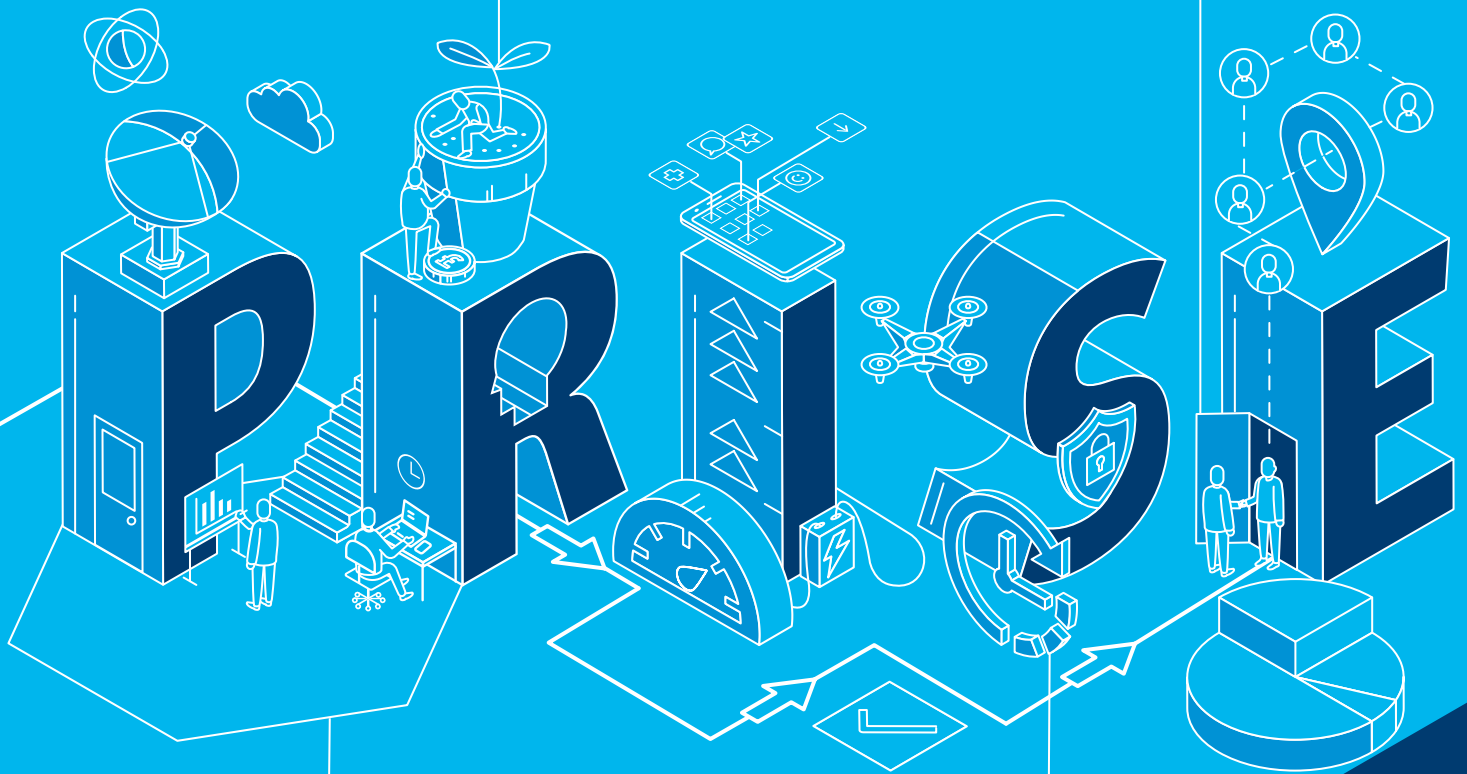
Offering specialist support with project management and commercial governance, including legal issues, finance, risk-management and public engagement, our professional teams work with academics and businesses on complex projects, startups and commercial ventures, from scoping and negotiation through to project delivery and project closure.

TALENT AND IDEAS

We are home to a talented generation of entrepreneurial students and researchers. Industry collaborators can meet the community and discover their technologies, ideas and talent by working with our entrepreneurship programmes and accelerators. There are many ways to get involved, from attending events to mentoring entrepreneurs or sponsoring entire programmes.

MEMBERSHIP THAT OPENS DOORS

As part of our corporate membership network, you will have access to a range of specialist services and member events curated specially for you. Through tailored advice, training, technology showcases and events, we'll guide you through Imperial's innovation landscape to find exactly what your business needs.



A COMMUNITY OF ENTREPRENEURS

Our business growth hubs offer specialised startups and established companies the chance to be part of a community of west London innovators, with opportunities to network, share ideas and access training and support. The community is supported with space and facilities including meeting rooms, wet labs and prototyping equipment.

FUTURE INSIGHTS

Want to future-proof your business? With access to Imperial's cutting-edge research and visionary academics, we can help you understand the impact of new technologies and scientific breakthroughs, bringing to life possible, plausible and probable futures – and helping your business stay ahead of your competitors.

www.imperial.ac.uk/enterprise

A YEAR OF ENTERPRISING ACTIVITY

1 AUGUST 2018 – 31 JULY 2019

TABLE 1A: STUDENT STARTUPS 2018–19

| Startup | Concept |
|--|---|
| BIOTECHNOLOGY & MEDICAL RESEARCH | |
| BrightCure | BrightCure aims to treat recurrent urinary tract infections using probiotics as a treatment to kill bacteria in the bladder. |
| IO Cybernetics | IO Cybernetics are building next-generation prostheses and human-computer interfaces. |
| Spyras | Paper-based sensors to monitor breathing rates, volumes and gases on patient's breath in order to provide more detailed information to clinicians about their health. |
| COMPUTERS, PHONES & HOUSEHOLD ELECTRONICS | |
| Mind2Matter | Mind2Matter have created earphones engineered to understand you and your music tastes by monitoring your brain's responses to music and making better recommendations. |
| FOOD | |
| Jelly Drops | Jelly Drops are vegan sugar free sweets boosted with electrolytes, designed with dementia sufferers in mind to tackle high levels of dehydration. |
| Mighty Drinks | Mighty Drinks have crafted the UK's first chilled ready-to-drink plant-based tea lattes, brewed with Fairtrade, organic ingredients. |
| HEALTHCARE EQUIPMENT & SUPPLIES | |
| Haptic Illusion | A tactile device that uses virtual reality to create a fully immersive education environment for medical students. |
| NoBlu | NoBlu produce fashionable and sustainable frames that house blue light filtering lenses for safe screen viewing. |
| Novonomics | Novonomics provides business consulting services and is also designing medical devices. |
| TheMoment | A non-invasive wearable device for Parkinson's utilising pulsed cueing and focused vibrotactile stimulation to reduce symptoms of slowness and stiffness, resulting in improved movement. |
| Unhindr | A wearable robotic liner for prosthetics that uses artificial intelligence to learn comfort settings and adapts to them automatically throughout the day. |
| VUI Diagnostics | Making avoidable blindness a thing of the past by improving access to community eye screening using their patent-pending, portable plug-and-play device and software. |
| HEALTHCARE PROVIDERS & SERVICES | |
| HealthUK | HealthUK is building an online platform to make healthcare screening more effective. |
| Mangetoo | A bespoke digital platform for making more personalised choices for evidence-based diets. |
| Nutritank | Nutritank is an innovation hub for food, nutrition and lifestyle medicine. |

| Startup | Concept |
|---|---|
| HOTELS & ENTERTAINMENT SERVICES | |
| Swoop Meals | Delicious and affordable meals to residents of London for a price of £2 directly from chefs. |
| INVESTMENT BANKING & INVESTMENT SERVICES | |
| Nodes.World | Nodes.World is providing analyst coverage and research for private capital markets. |
| PASSENGER TRANSPORTATION SERVICES | |
| Dash Rides | A corporate branded electric bike subscription service which empowers employees with a convenient alternative to public transport. |
| PERSONAL & HOUSEHOLD PRODUCTS & SERVICES | |
| Sweren | Sweren is all about bringing the beauty of nature into daily lives through original and unique items such as wooden wallets and bracelets. |
| Tempo Market | Tempo Market is a camping equipment rental service that delivers directly to the campsite. |
| PROFESSIONAL & COMMERCIAL SERVICES | |
| Be A Maker | MakeLabs is pioneering in the Mindful Creativity industry by guiding their users to engage with a creative and an artistic activity for the benefit of their mental health. |
| Coillection | Coillection is revolutionising oil recycling in the UK by offering households a simple oil drop-off and collection service. |
| Community | Community is a digital common room and notice board created by students for students. |
| PeerRecruiter | PeerRecruiter is a peer-to-peer interview platform, powered by industry experts, allowing companies to hire better talent, faster. |
| Pelation | Pelation is using innovative design and engineering to build the newest, safest, smartest, self-learning bike light and dashcam for urban cyclists. |
| Pluvo | The Pluvo is a patent-pending product with an in-built filtration system capable of reducing harmful particulate matter and gases present in city streets. |
| Resolv Dispute Management | Resolv Dispute Management have developed an online dispute resolution platform. |
| Studio Lära | STUDIO LÄRA is developing friendly and accessible learning materials aimed at developing key future skills. |
| ENERGY | |
| Calortech UK | Calortech encourages the adoption of; and investment into; sustainable energy assets such as energy efficiency, distributed generation and storage. |
| SPECIALITY RETAILERS | |
| Wandering Tern | A travel book subscription service, highlighting authors from different countries and bringing the world to people. |

Table 1A continues overleaf

| Startup | Concept |
|------------------------------|--|
| SOFTWARE & IT SERVICES | |
| AA Nexus | Offers an unbiased independent review of corporate governance structures to gain trust of global financial markets and stakeholders. |
| Abnormal Design | A computational art and design studio who craft beautiful algorithms that manifest as things you can touch, hear and experience. |
| AgriLabs Connect | A mobile app that provides easy access to nearby agricultural lab services such as soil, feed and water analysis. |
| AirWire | This new smart system reads finger gestures and turns them into code to help to make programming electronics more accessible. |
| Arthronica | Arthronica aims to use computer vision to prevent chronic pain and support doctors in diagnosis and treatment of arthritic conditions. |
| Breathe Battery Technologies | Breathe Batteries are making charging faster and safer with adaptive algorithms which consider the unique and evolving condition of every battery. |
| Compass E-Learning | The Compass platform addresses the need to create sustainable, regenerative and thriving futures through helping people learn in more diverse and accessible ways. |
| eShelf | Allows shoppers to browse the best products from across different stores and automatically reserves them for collection. |
| Ethi Technologies | A free and secure tool to allow individuals to find out more about their online presence through the analysis of their facebook data. |
| Glasshouse Global | Glasshouse is a mobile app powered by AR that helps you find offers in your local area. |
| Intellisense | Intellisense provides a broad range of analytics services to investigate past business performance to gain insight and drive business planning. |
| Jacobian Solutions | Jacobian Solutions is focused on creating innovative technology solutions that help customers achieve more in their everyday lives. |
| Move.ai | Reinventing sports data by combining computer vision, AI and machine learning to create enterprise software solutions from real-time performance data. |

| Startup | Concept |
|------------------------------------|--|
| SOFTWARE & IT SERVICES | |
| NeuralSpace | NeuralSpace is ensuring that research-level AI solutions reach the industries that need them. |
| Project Automobility | Project Automobility is researching the impact of automotive-based mobility to design solutions for physically navigating an increasingly complex world. |
| SSC Analytics | SSC Analytics improves student performance and satisfaction in secondary education by analysing the data students generate over their studies. |
| Schoolx | An edtech startup training teachers and connecting them to students for face-to-face classes in a venue chosen from their extensive space network. |
| Signus Analytics | A data science team building a track record of success driving innovation at some of the biggest firms in the UK by offering data science as a resource. |
| Sleeponea | Using a data-driven intelligent platform, Sleeponea diagnoses sleep apnoea and assists both patients and clinicians in managing personalised treatment. |
| SOCRATES | The team behind this startup are hoping their AI tool will empower medical students to become better doctors by developing their consultation, diagnostic and clinical reasoning skills. |
| Yokeru | An AI-based triage platform which makes human-like phone calls to the most vulnerable households in our communities and utilises data on wellbeing to help local government, care organisations, and health systems. |
| TEXTILES & APPAREL | |
| HydroCotton | Growing radically sustainable cotton using technology that reduces the water and fertilisers needed by up to 80%. |
| WATER & OTHER UTILITIES | |
| FilterNow | A compound that could be introduced to filtration systems to attract and trap microplastics, preventing them from entering the environment. |

TABLE 1B: IP STARTUPS* FORMED IN 2018–19

| Startup | Concept |
|-----------------------------------|---|
| PHARMACEUTICALS | |
| Zhipp | Transforming the lives of patients with diabetes and obesity by developing safe and effective weight loss therapies. |
| ENERGY | |
| Solar Flow | Integrating two existing solar energy technologies into a single solar panel, reducing energy costs and carbon footprint. |
| SOFTWARE & IT SERVICES | |
| Insendi | A sector-leading learning platform developed with expertise in course development, staff training and consultancy. |

*Based on assignment of College IP into the company

TABLE 2: PROGRESS OF IMPERIAL STARTUPS 2018–19

| Criteria | IP startups | Student startups | Total |
|--|-------------|------------------|-------------|
| Number of active startups (as of 31 July 2019) | 72 | 151 | 223 |
| Investment funds secured in 2018–19 (£ million) | 21.6 | 27.7 | 49.3 |

TABLE 3: TEN NOTABLE EXAMPLES OF STARTUP SUCCESSES 2018–19

| Startup | Context |
|------------------|---|
| GraphicsFuzz | Academic startup acquired by Google |
| Jelly Drops | Awarded £30,000 prize through EIT Food Global Venture Programme |
| Notpla | Ooho product trial on London Marathon |
| Mitt | Pilot launched of arm prosthetics |
| Spyras | £10,000 Mayor of London Entrepreneur Award |
| Trik | Pae Natwilai – Software Engineer Award – FDM everywoman in Technology Awards |
| Purraffinity | Gabriella Santosa and Henrik Hagemann – Forbes 30 Under 30 – Europe – Manufacturing & Industry 2019 |
| Ichthion | Inty Grønneberg – MIT Technology Review Latin America Inventor of the Year |
| LYS Technologies | Christina Blach Peterson – MIT Innovators Under 35 |

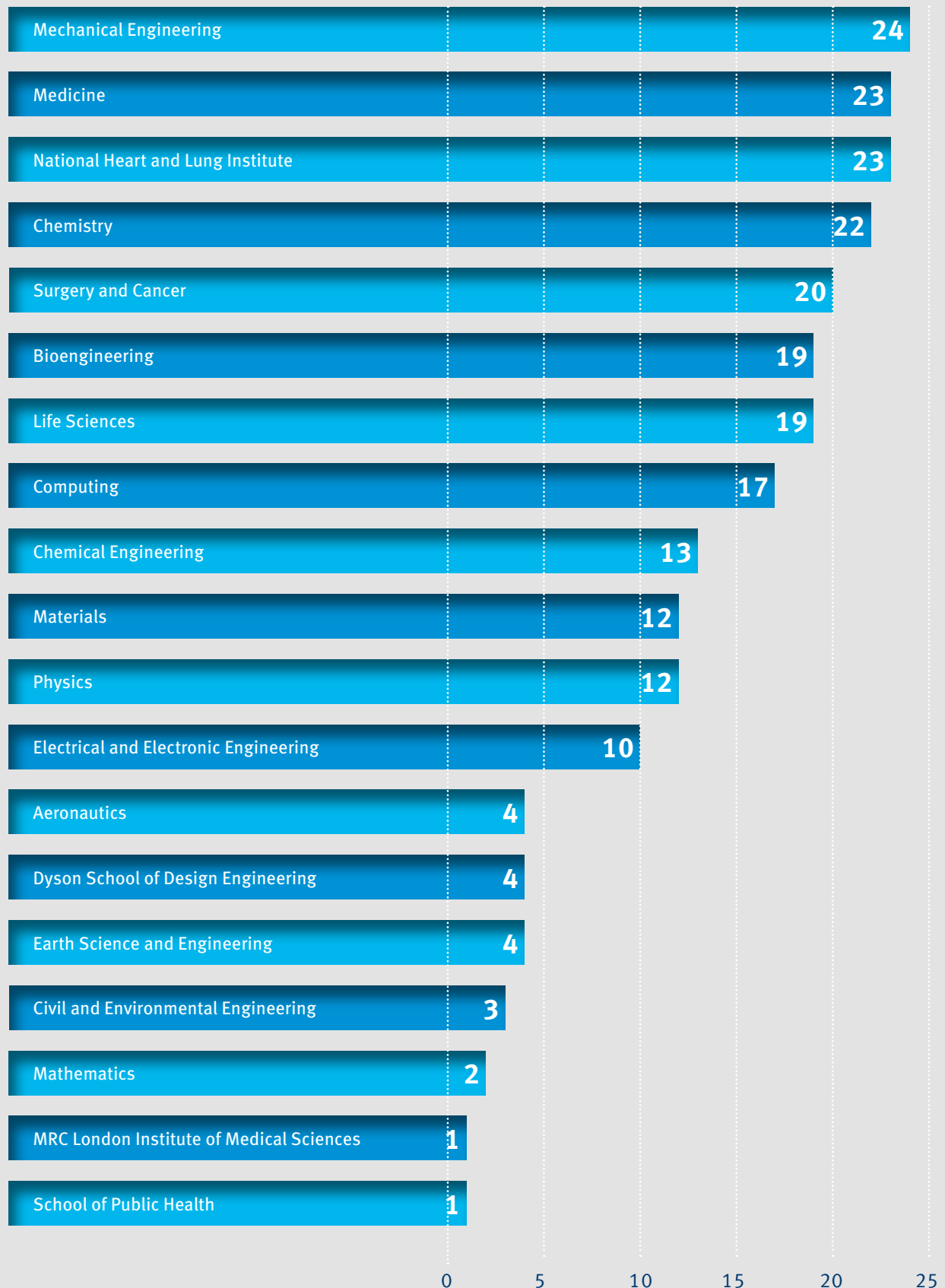
TABLE 4: STARTUPS IN THE WHITE CITY INCUBATOR AS OF JULY 2018

| Startup | Context |
|---|---|
| CHEMICALS | |
| FreshCheck | Quick confirmation of bacterial contamination with clear colour change. |
| Polymateria | Biodegradable, recyclable, customisable and cost-effective plastics, beating global pollution. |
| HEALTHCARE EQUIPMENT & SUPPLIES | |
| Cytera | Cytera have built an automated, low-cost cell culture system that can be stacked and controlled remotely, designed to reduce the amount of labour in laboratories. |
| MediSieve | Drug-free malaria treatment using magnetic blood filtration. |
| Sixfold | Sixfold are developing safe and effective drug delivery systems for cell and gene therapeutics. They are developing technology to deliver high doses of medication direct to tumours, rather than affecting the healthy cells of cancer patients. |
| Smart Respiratory | Peak flow meter devices for mobile health solutions for asthma management. |
| HEALTHCARE PROVIDERS & SERVICES | |
| SIME DX (SIME Diagnostics) | Realising the potential of photonics and machine learning in clinical diagnostics. |
| Therapeutic Frontiers* | Human rhinovirus experimental infection model for studies in human asthma and COPD. |
| MACHINERY, TOOLS, HEAVY VEHICLES, TRAINS & SHIPS | |
| Addionics | Developing a smart 3D structure for use in batteries to decrease charge time and increase the lifetime and range of the battery. |
| HayBeeSee | Developing affordable, always-on aerial robot which works in farms doing a variety of unautomated tasks. Their 'crop-hopper' drone is utilising a novel movement system to increase functionality and decrease operational risks and cost. |
| PHARMACEUTICALS | |
| Affinity Laboratories | Diagnostics and therapeutics through biomarker discovery. |
| Axitan | Veterinary vaccines and peptides from microalgae. |
| GammaDelta Therapeutics | Harnessing gamma delta T cells from improved immunotherapies for cancer and other serious diseases. |
| Pulmocide* | Inhaled anti-infectives for targeted treatment of life-threatening lung infections. |
| Puraffinity | Targeted filtering technology for micropollutants. |
| ENERGY | |
| SweetGen* | Creating energy from waste water with innovative catalyst technology. |

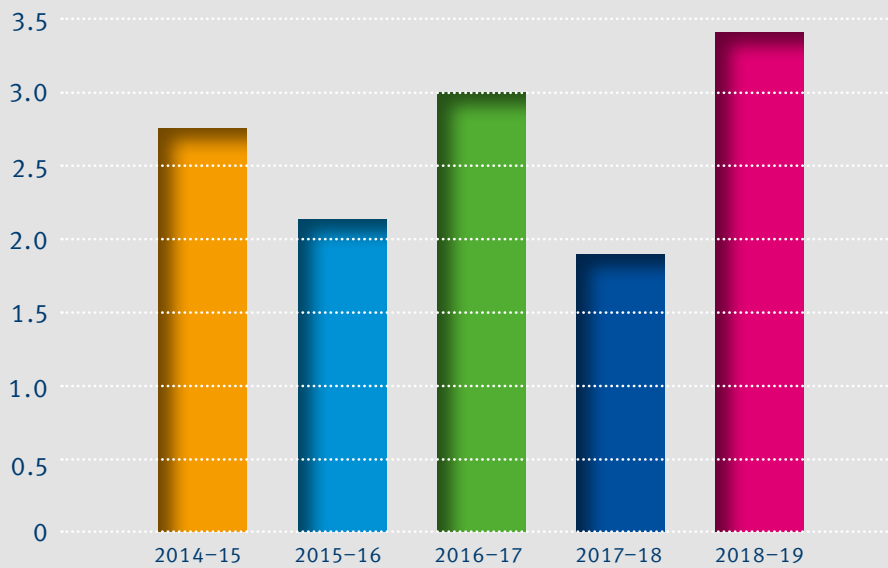
* Indicates an affiliation with Imperial through IP

ENTERPRISING ACTIVITY DATA 2018–19

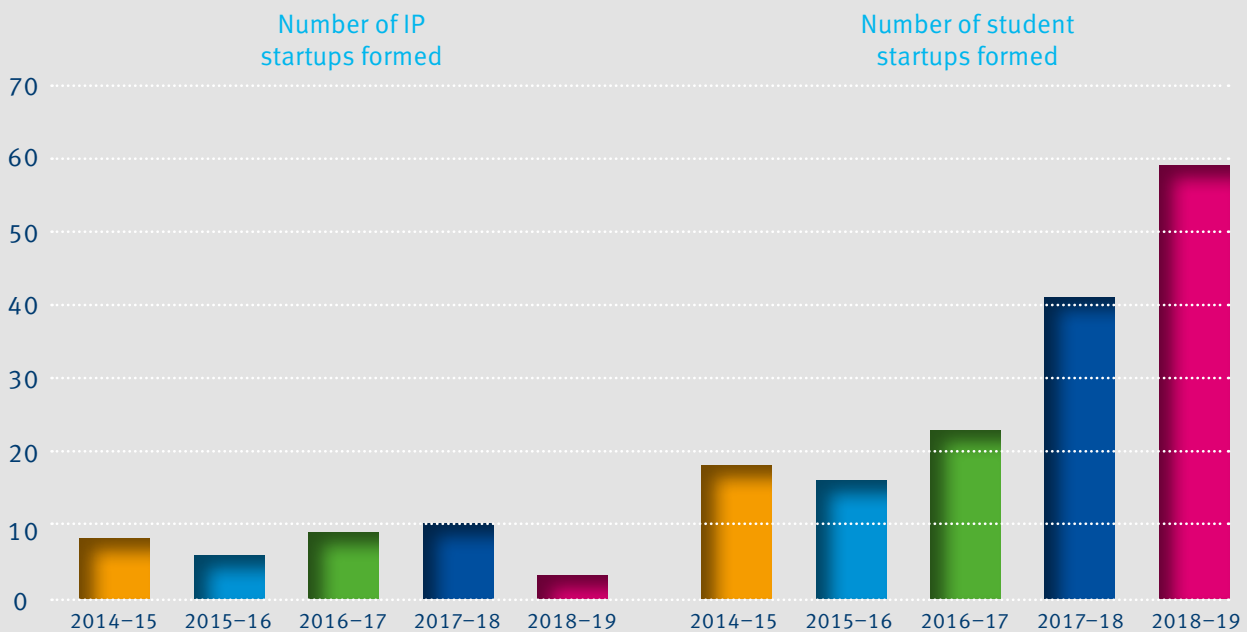
DISTRIBUTION OF INVENTION DISCLOSURES BY ACADEMIC DEPARTMENT AT IMPERIAL



LICENSING REVENUE (£ MILLION) AT IMPERIAL COLLEGE LONDON 2014 – 2019



NUMBER OF IP AND STUDENT STARTUPS FORMED AT IMPERIAL 2014-19



NOTABLE TRENDS

Industry research partnerships

Industry research partnerships have continued to grow, maintaining a positive long-term trend. Although the sector classification approach has changed, engagement by sector is broadly stable versus the year prior. The bulk of awards continue to come from pharmaceutical and biotechnology companies, representing more than a quarter of the total number of active projects. Engagement with heavy industrial sectors such as chemicals, oil and gas, machinery, and aerospace also continues to be strong and makes up a considerable proportion of overall engagement.

Inventive output, licensing and IP-based startups formed

A major changeover in technology transfer was implemented in early 2019, as activities were brought in-house from Imperial Innovations. New processes were adopted to

optimise our technology transfer commercial activities within Enterprise. We established a robust invention disclosure system to guide us through the various stages from Disclosure to Commercialisation. As a result, some of our metrics have changed (see scorecard on p. 27). Despite the changes, last year we filed a total of 85 new patent filings based on technologies developed at Imperial College London and 63 patents were granted. Our active patent portfolio (excluding commercialised patent families) of 332 patent families indicates a healthy pipeline of good commercialisation prospects. In 2019 we completed the formation of three new IP startups: Zihipp, Solar Flow and Insendi, based on work undertaken at the Faculty of Medicine, Engineering and Business School taking our IP Startups Portfolio to a total of 72 companies.

Student startups

Student startup formations continues its year-on-year growth, with a 49% rise in the number of startups formed.

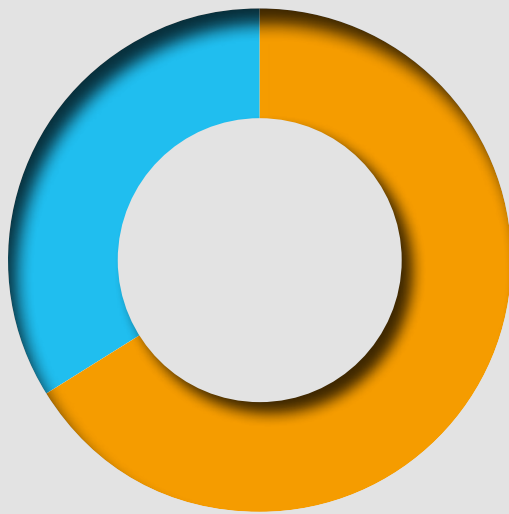
Consulting

Academic consultancy activities through Imperial Consultants grew across all key metrics versus the year prior. The number of companies supported increased by 22% to 494 companies. The number of lead consultants increased by 15% to 330, indicating growth in Imperial Consultants' internal client base. The number of projects increased by 21% to 666 and overall consulting income grew by 12%, reaching just over £10m.

Industry classification

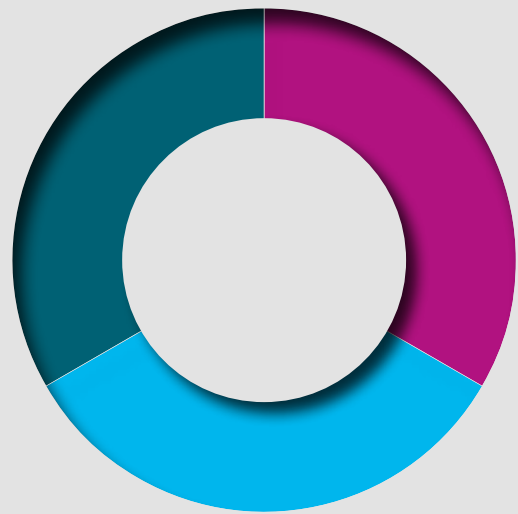
This year categorisation of industry sectors has adopted a new classification methodology.

IMPERIAL CONSULTANTS – UK AND NON-UK PROJECTS 2018–19



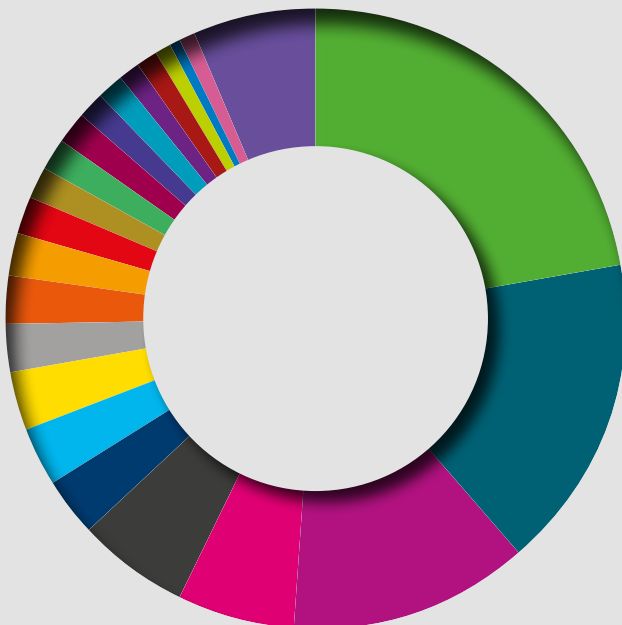
- UK client projects
- Non-UK client projects

IP STARTUPS FORMED IN 2018–19 BY SECTOR



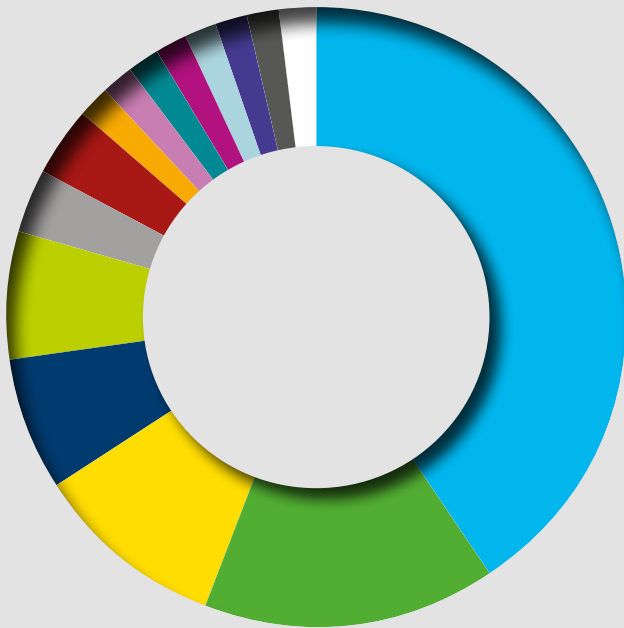
- Energy
- Software & IT services
- Pharmaceuticals

IMPERIAL CONSULTANTS PROJECTS 2018–19 BY SECTOR



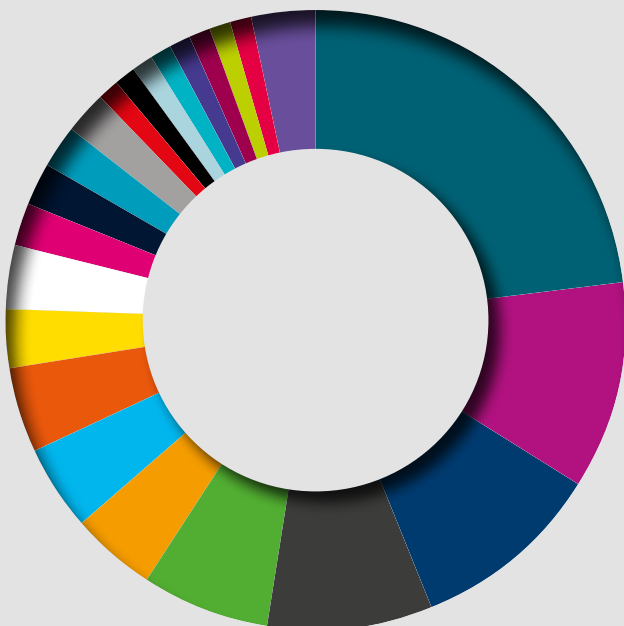
| | | |
|--|-----|-----|
| ● Professional & Commercial Services | 115 | 22% |
| ● Pharmaceuticals | 85 | 16% |
| ● Energy | 65 | 13% |
| ● Construction & Engineering | 31 | 6% |
| ● Aerospace & Defence | 30 | 6% |
| ● Biotechnology & Medical Research | 17 | 3% |
| ● Software & IT Services | 16 | 3% |
| ● Healthcare Equipment & Supplies | 15 | 3% |
| ● Personal & Household Products & Services | 13 | 3% |
| ● Machinery, Tools, Heavy Vehicles, Trains & Ships | 13 | 3% |
| ● Chemicals | 11 | 2% |
| ● Automobiles & Auto Parts | 10 | 2% |
| ● Metals & Mining | 9 | 2% |
| ● Electronic Equipment & Parts | 9 | 2% |
| ● Industrial Conglomerates | 8 | 2% |
| ● Investment Banking & Investment Services | 8 | 2% |
| ● Media & Publishing | 7 | 1% |
| ● Insurance | 6 | 1% |
| ● Food | 5 | 1% |
| ● Healthcare Providers & Services | 5 | 1% |
| ● Banking Services | 3 | 1% |
| ● Transport Infrastructure | 3 | 1% |
| ● Other | 33 | 6% |

STUDENT STARTUPS 2018–19 BY SECTOR



| | | |
|---|-----------|-----|
| Software & IT Services | 24 | 41% |
| Professional & Commercial Services | 9 | 15% |
| Healthcare Equipment & Supplies | 6 | 10% |
| Biotechnology & Medical Research | 4 | 7% |
| Healthcare Providers & Services | 4 | 7% |
| Personal & Household Products & Services | 2 | 3% |
| Food | 2 | 3% |
| Water & Other Utilities | 1 | 2% |
| Textiles & Apparel | 1 | 2% |
| Speciality Retailers | 1 | 2% |
| Energy | 1 | 2% |
| Passenger Transportation Services | 1 | 2% |
| Investment Banking & Investment Services | 1 | 2% |
| Hotels & Entertainment Services | 1 | 2% |
| Computers, Phones & Household Electronics | 1 | 2% |
| Total | 59 | |

INDUSTRY INCOME 2018–19 BY SECTOR



| | |
|--|-----|
| Pharmaceuticals | 21% |
| Energy | 10% |
| Biotechnology & Medical Research | 9% |
| Aerospace & Defence | 8% |
| Professional & Commercial Services | 6% |
| Chemicals | 4% |
| Software & IT Services | 4% |
| Machinery, Tools, Heavy Vehicles, Trains & Ships | 4% |
| Healthcare Equipment & Supplies | 3% |
| Computers, Phones & Household Electronics | 3% |
| Construction & Engineering | 2% |
| Communications & Networking | 2% |
| Media & Publishing | 2% |
| Personal & Household Products & Services | 2% |
| Automobiles & Auto Parts | 1% |
| Office Equipment | 1% |
| Passenger Transportation Services | 1% |
| Construction Materials | 1% |
| Investment Banking & Investment Services | 1% |
| Industrial Conglomerates | 1% |
| Healthcare Providers & Services | 1% |
| Beverages | 1% |
| Other | 3% |

DIRECTOR'S LETTER

In early 2019, Imperial made several moves to take its commercial activity and entrepreneurship to the next level. We started to lead on technology transfer ourselves, bringing the previously external organisation in-house, opening up our startups to a wider range of investors.

We also brought consultancy, incubation, and hackspace facilities together with existing commercialisation work to strengthen connections across our entrepreneurial ecosystem, making it easier for you to work with a broader range of academics and students.

This level of reorganisation has inevitably led to a bedding-in period while we establish new systems and synergies. And I am delighted to report that the changes are starting to bear fruit, as this edition of the *Review* evidences.

Companies looking for a supportive way to connect with the College have signed up to the Imperial Business Partners programme, which provides support to navigate a variety of specialist advice

from Imperial's academic experts. We have been delighted to welcome a new cohort of banks and other financial services companies to the programme this year, and look forward to hearing from you if accelerated access to the best of Imperial's people, technologies, expertise and facilities could support your business.

The reorganisation has enabled us to open up investment opportunities to a fuller range of investors, with the newly established Investor forum offering members an exclusive opportunity to hear from staff and student startups on a regular basis. Earlier this year we also launched the Imperial College Innovation Fund, providing opportunities to invest in early-stage, high-growth, knowledge-intensive companies.

For those of you interested in furthering research, we offer an expanded portfolio of partnership and licensing opportunities. Our recently launched technology portfolio platform –

Imperial.tech – highlights some of the best technologies coming out of the College at the moment.

Imperial's innovation under lockdown has been inspiring and humbling, with an amazing diversity of COVID-beating technologies accelerated into clinical trials and use. As we continue to adapt and respond to COVID-19, we will particularly be examining how best to collaborate at an international scale. We look forward to increasing the number of companies we work with, whatever the route. Please do connect with us to explore what we can offer you.

Dr Simon Hepworth
Director of Enterprise
Imperial College London



ENTERPRISING ACTIVITY SCORECARD 2018-19

| Metric | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 |
|--|---------|---------|---------|---------|---------|
| RESEARCH INCOME | | | | | |
| Research income (£ million) | 436 | 351 | 361 | 364 | 368 |
| Industry research income (£ million) | 55.7 | 53.6 | 61.1 | 61.4 | 64.8 |
| INVENTIVE OUTPUT | | | | | |
| Inventions disclosed ¹ | 296 | 310 | 332 | 376 | 233 |
| Patents filed (new patent applications + PCT applications) | 110 | 116 | 121 | 125 | 153 |
| Patents issued | 47 | 59 | 49 | 47 | 63 |
| Invention disclosure portfolio ² | 1007 | 1021 | 1009 | 1026 | 980 |
| Active patent portfolio ³ | 394 | 404 | 405 | 435 | 332 |
| LICENSING AND IP PERFORMANCE | | | | | |
| New agreements signed ⁴ | 39 | 39 | 46 | 43 | 21 |
| Invention Disclosures (IDS) licensed | 60 | 48 | 86 | 63 | 37 |
| Active licences held | 211 | 211 | 232 | 230 | 231 |
| Licences generating income in the period | 74 | 70 | 64 | 71 | 61 |
| Total IP income (£ million) ⁵ | 4.7 | 3.7 | 9.6 | 3.5 | 5.9 |
| STARTUP FORMATION | | | | | |
| IP startups formed ⁶ | 8 | 6 | 9 | 10 | 3 |
| Student startups formed | 18 | 16 | 23 | 41 | 59 |
| STARTUP INVESTMENT | | | | | |
| IP startup investment received (£ million) ⁷ | 363.4 | 113.7 | 123.4 | 87.5 | 21.6 |
| STARTUP COMPANIES PERFORMANCE | | | | | |
| IP startups still active | 74 | 70 | 76 | 79 | 72 |
| Income from sale of shares in IP startups (£ million) | 1.9 | 1.6 | 6.6 | 1.6 | 2.1 |
| Current turnover of all active IP startups (£ million) ⁸ | 33.6 | 48.2 | 80.2 | 147.3 | 22.2 |
| Jobs supported directly by IP startups | 814 | 1002 | 974 | 1273 | 835 |
| STUDENT STARTUP PERFORMANCE | | | | | |
| Capital acquired by student-based startups (£ million) | 5.0 | 9.7 | 5.1 | 17.6 | 39.7 |
| Student-based startups still active | 29 | 44 | 66 | 122 | 151 |
| Current turnover of student-based startups (£ million) ⁹ | 1.4 | 2.8 | 1.2 | 2.1 | 3.1 |
| Jobs supported directly by student-based startups ¹⁰ | 89 | 51 | 40 | 64 | 350 |
| INCUBATION PERFORMANCE | | | | | |
| Startups housed by university incubators | 18 | 13 | 9 | 19 | 19 |
| Startups graduated from an incubator programme ¹¹ | 2 | 4 | 10 | 1 | 2 |
| Active incubator graduate companies | 17 | 21 | 31 | 29 | 31 |
| MAJOR PROJECTS | | | | | |
| No. of ventures supported | | | | 14 | 18 |
| CONSULTANCY AND TECHNICAL SERVICES | | | | | |
| No. of consultancy projects | 549 | 522 | 543 | 550 | 666 |
| Annual consultancy income (£ million) | 9.7 | 9.3 | 8.5 | 9.0 | 10.1 |
| No. of companies supported through consultancy | 408 | 414 | 412 | 405 | 494 |
| No. of lead consultants | 287 | 289 | 284 | 287 | 330 |
| CORPORATE MEMBERSHIP SERVICE | | | | | |
| Imperial Business Partners member companies | 14 | 14 | 11 | 19 | 19 |
| RATIOS¹² | | | | | |
| Invention disclosures per £100m of research income | 68 | 88 | 92 | 103 | 63 |
| Patents filed per £100m research income | 15 | 21 | 19 | 21 | 23 |
| Patents issued per £100m research income | 11 | 17 | 14 | 13 | 17 |
| Licensing and realisation income: research income (%) | 1.1 | 1.1 | 2.7 | 1.0 | 1.5 |
| IP startups per £100m research income | 1.8 | 1.7 | 2.5 | 2.7 | 0.8 |
| Student startups / 1000 students in student population (full-time and part-time) | 1.1 | 0.9 | 1.8 | 2.2 | 3.1 |

¹ 2018-19 number is based on staff and student inventions disclosed, prior years based on staff only.

² Invention Disclosure Portfolio of Imperial IP, Student IP and IPG excluding Invention in Evaluation Stage (not part of patent portfolio).

³ 2018-19 number is based on staff and student data, prior years based on staff only.

⁴ The numbers represents the overall commercial IP agreements (which includes Licences, Options, Revenue shares and IP assignments). Licensing numbers are reported on the next line for clarity.

⁵ Total IP income includes royalties and fees from IP, income from sale of shares in IP

startups and other forms of IP income.

⁶ For context on changes to organisational and process changes affecting technology transfer in 2018-19, please see Notable Trends on p.23.

⁷ and ⁸ 2018-19 figure influenced by some large exits from the startup portfolio.

⁹ Includes a large number of early-stage companies.

¹⁰ 2018-19 figure includes part-time staff (each counted as 0.5 Full-Time Equivalent).

¹¹ One time effect in 2016/17 as a result of closing Imperial's South Kensington incubator.

¹² Ratios do not include PCT applications.

Imperial College London is one of the world's leading universities. The College's 18,000 students and 8,000 staff are expanding the frontiers of knowledge in science medicine, engineering and business, and translating their discoveries into benefits for our society.

Imperial is the UK's most international university, according to *Times Higher Education*, with academic ties to more than 150 countries. In 2019, Reuters named the College as the UK's most innovative university because of its exceptional entrepreneurial culture and ties to industry.

This report covers work carried out since 1 August 2019, with data and metrics (pp. 4-5, 15-25 and 27) for the College year 1 August 2018 – 31 July 2019. The work represented here was carried out by Imperial academics, students and professional services, including the College's Enterprise Division, Research Office, Research Services and external providers such as Imperial Innovations. The College would like to thank all industrial collaborators, past, present and future, for partnering with us and helping to realise research-based opportunities to improve the quality of all our lives.

imperial.ac.uk/enterprise
