

Imperial College
London

ENTERPRISE

Review of
ENTERPRISING ACTIVITY

2017–18

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It gives me great pleasure to introduce Imperial's second Review of Enterprising Activity. Our goal is to share what the College is doing in this important area, and to continue tracking our performance over time. We also want to show how enterprise takes place at Imperial, and the high value we place on innovation and entrepreneurship.

Imperial's focus on deep science and technology means that a much higher proportion of our staff and students are interested in innovation and entrepreneurship than at many other universities.

While Imperial benefits from a natural groundswell of entrepreneurial endeavour, this activity still requires encouragement and support. Our ways of working have had to evolve. In the past, companies gave us problems to work on and waited patiently for an answer. Now we see new modes of engagement, with researchers from our corporate partners coming into our laboratories to work alongside us, and our staff going to work in corporate labs.

We also organise hackathons to bring staff from businesses together with some of our brightest minds to work together on solving specific issues in a focussed way over a short period of time.

Then there are more staff who want to create their own companies, and who need practical guidance and active support.

Our students are also increasingly interested in innovation and entrepreneurship. Many already have business ideas that they want to pursue; we talk to them about forming a company, protecting their innovations and securing funding.

The most committed can enrol in the Enterprise Lab to develop their ideas further, and then test their proposals through startup competitions. If successful, the startups can join Imperial's White City Incubator and later scaleup in the Translation & Innovation Hub. We are starting to see innovations and entrepreneurs who are completing that journey – just a handful at the moment, but with more to come.

The whole ethos at White City is that staff, students and business people should work side by side. It is not simply a university campus, nor a science park remote from the university, but a place for sustained and meaningful interaction.

I know from my own experience as an entrepreneurial academic how important it is to listen to people who understand the market. It is easy to think that world-leading science will inevitably lead to commercial success,

but that is not always the case. You have to identify your market niche and know how your science will make a difference. Contacts with companies, either at White City, through research partnerships or our network of business mentors, are how we bring that market experience into the College.

Above all, it is important to consider the whole entrepreneurial journey. Implementing a comprehensive support programme for student entrepreneurs or building an excellent business incubator are not enough in isolation. All the elements need to be in place so that people can move naturally along a pipeline from one to another, creating a healthy environment in which entrepreneurship can flourish.

At Imperial we have worked in a number of ways to achieve that. For example, innovation initiatives have developed across the College in response to local needs, but with slightly different ways of working. The challenge has been to bring structure and coherence to these activities, without stifling them.

We have also made an effort to fill in gaps. For example, we felt that while staff and students were well-supported, there was less support for our community of early career researchers. The result has been two programmes to help this highly innovative community to hone their entrepreneurial skills.

We do all this because we want our research to make a difference. Our reward comes from seeing our research put to good use, and the intellectual stimulation of engaging with business. For every problem we solve or question we answer, a range of new research challenges opens up.

Imperial aspires to be one of the world's leading innovative and entrepreneurial universities, and it is gratifying when rankings and league tables confirm our achievements. But they should just confirm, rather than shape our agenda. If we are authentic about what we are doing, and we are doing it for the right reasons, then the ratings and plaudits will follow.



Professor Nick Jennings, Vice-Provost (Research and Enterprise)

Front cover: Pae Natwilai (MSc Mechanical Engineering 2015) is founder and CEO of TRIK, which produces software for creating interactive 3D maps of large structures from drone footage. Pae originally developed TRIK as a project for WE Innovate, Imperial's programme to encourage entrepreneurial women. Since then she has developed and launched her business with the help of both the Enterprise Lab (page 20) and the Imperial Venture Mentoring Scheme (page 23). In 2017, she won the Design in Innovation Award, and was named as one of Forbes' 30 under 30.

ENTERPRISE AT A GLANCE



IMPERIAL'S BUSINESS NETWORK

Members of Imperial Business Partners (IBP) explored technologies of the future at Imperial's flagship annual technology foresight conference Shifting Realities in June 2018. Powered by IBP and curated by Imperial Tech Foresight, the conference explored how companies can adapt to technology-enabled futures.

IBP offers accelerated access to the best of Imperial's people, technologies, expertise and facilities.

Find out what IBP can do for your business at www.imperial.ac.uk/ibp



FAST-TRACKING BUSINESS IDEAS FROM EARLY CAREER RESEARCHERS

Ms Letizia Gionfrida (Bioengineering) is one of the Imperial researchers selected for cohort one of the MedTech SuperConnector (page 16). She is developing an intuitive, visual-based digital platform that is powered by neural networks to identify biomarkers in immune-mediated inflammatory diseases. This could lead to a supplementary tool for faster screening, as well as remote monitoring of disease progression, and predictive treatment as a result of continuously measuring how the patient responds to drugs.

CONNECTING GROWING BUSINESSES TO STUDENT TALENT

In 2017–18, Imperial's Careers Service partnered with Santander Universities to provide SMEs with streamlined access to Imperial's student talent, via paid, project-based internships for undergraduates. "This internship was a valuable experience as it has given me both technical and professional skills and has enabled me to get a clearer picture of how it is to work in the industry," said one of the student interns.



DISCUSSING SCIENTIFIC SOLUTIONS WITH WORLD LEADERS

Professor Gary Frost, and Drs Marisa Miraldo and Laura Barter, shared their pioneering work on nutrition and food production with global leaders at the Annual Meeting of the World Economic Forum (WEF) in Davos-Klosters in January 2018. Imperial regularly engages with WEF political and business leaders on topics represented by the College's research networks of excellence.

Discover the full range of Imperial's Networks of Excellence at www.imperial.ac.uk/multidisciplinary-research

TACKLING FUTURE CHALLENGES

Leading scholars from the Schmidt Science Fellows Programme took part in an Imperial Tech Foresight workshop on the future of urbanisation to explore potential solutions to future global challenges. Imperial Tech Foresight works with businesses and researchers to help them consider alternative futures and apply this thinking to their own work. "This workshop has taught me the practice of thinking about future scenarios," said workshop participant Fred Richardson.



IMPACT FROM A LONG-TERM PARTNERSHIP

Imperial's partnership with Mitsubishi Heavy Industries (MHI) on turbocharger design began as a collaboration with Professor of Turbomachinery Ricardo Martinez-Botas (above) in 2005. It has led to substantial improvements in turbine performance as a result of more advanced measurement techniques and simulation tools. "Good quality R&D is the bedrock of our business. In Imperial we have found a longstanding partner who can help us to deliver cutting edge products," said MHI's Seiichi Ibaraki.



EXECUTIVE EDUCATION

Last year, Imperial College Executive Education ran 12 Open Programmes for over 200 business leaders from more than 25 countries. The department also worked with more than 15 blue-chip companies to develop and tailor Custom Programmes for their high performing leaders. One example was an experiential 'digital hothouse' where business leaders worked in cross-functional teams with coders and app developers to prototype real digital innovations. Participants received feedback from coaches throughout the process, giving them the opportunity to reflect, adapt their behaviour and apply new learning.

FROM IDEA TO IMPACT

Imperial values collaborative research that combines complex real-world business challenges with academic curiosity and research rigour, to deliver tangible benefits for society. Working in partnership with industry to increase academic engagement in collaborative research and commercialisation lies at the heart of the College's entrepreneurial ecosystem.

Imperial offers companies many opportunities to work with the College. Corporate partnership activities connect the business interests of a wide range of companies with the College's research expertise. The aim is to make it easier for businesses to identify the most relevant academic experts and to design effective bespoke collaborations, such as 'popup' academic teams to work on challenge-led research programmes or flagship industry-funded centres.

Imperial offers businesses a unique depth and breadth of academic expertise across its four faculties and expanding cohort of multidisciplinary research centres and networks of excellence. These pull together expertise across College for tackling major challenges such as nutrition, or addressing emerging research areas such as artificial intelligence.

VITAL STATISTICS 2017-18

£61m

in research funding from industry

10

new IP startups

£942m

in venture capital to IP startups in the last five years

376

invention disclosures

Visit www.imperial.ac.uk/corporate-partnerships to find out more about how Corporate Partnerships connects businesses to researchers.

BOOST FOR MOLECULAR INNOVATION AT WHITE CITY

Agilent Technologies and Imperial signed a deal for a suite of equipment to promote research collaboration at the new Molecular Sciences Research Hub (MSRH) on Imperial's White City Campus. The agreement was the first corporate partnership for the MSRH, which provides a new research home for the Department of Chemistry, and brings together nearly 800 scientists, clinicians, engineers and business partners to collaborate in new ways to address common challenges in areas such as energy, healthcare and sustainability.

The Agilent agreement includes a new Agilent Measurement Suite and other instrumentation. It will enable interdisciplinary research into areas including clinical diagnostics, biopharmaceuticals, energy and chemicals, environmental science, food testing and agriculture, and materials research.

Agilent president and CEO Mike McMullen said: "Imperial plays a very important role in advancing a deeper understanding of the world through their lab instruction and research. We recognize the important contributions made by university scientific research to solve real-life challenges... It is an honour for Agilent to support Imperial in building an advanced scientific measurement and analytical laboratory on their new White City Campus."



CO-LOCATION IMPROVES HEART DISEASE DIAGNOSIS

A new type of collaboration between Imperial and US-based company HeartFlow aims to help physicians improve diagnosis of heart disease, by providing better information about coronary artery blockages and blood flow, which in turn will improve decisions about treatment. The collaboration involves co-locating a HeartFlow team at Imperial's BioMedical Image Analysis (BioMedIA) group, to pave the path for bringing the latest AI technology into clinical practice.

The partnership is led by Dr Ben Glocker (Computing, right), who said: "This collaboration provides us with the optimal infrastructure to go beyond publishing papers and turn our ideas into new clinical solutions."

Dr John H Stevens, President and CEO of HeartFlow, said: "I have no doubt that the combined expertise of the HeartFlow and Imperial teams will help accelerate turning cutting-edge science into ground-breaking products that can positively impact how patients with suspected heart disease are diagnosed and managed."



CORPORATE PARTNERSHIPS

JAPANESE BIOSCIENCE COLLABORATIONS

A partnership between Imperial and Japanese pharmaceutical company Shionogi aims to tackle hard-to-treat infections, by looking into how pathogens become resilient to treatments. The partnership is supporting two postdoctoral positions in the Medical Research Council (MRC) Centre for Molecular Bacteriology and Infection at Imperial.

Dr Sophie Helaine is one of the Imperial researchers leading work to investigate the mechanisms that make some infections so difficult to treat. Her work focuses on persister cells that enable pathogenic bacteria such as *Salmonella* to persist in the body in a dormant state, survive treatment, and then awake later to cause a relapse of the infection.

“This collaboration is the result of extensive conversations between Imperial and Shionogi,” said Dr Helaine. “The additional support of industry partners will enable us to intensify our efforts to tackle hard to treat infections, which could ultimately help reduce the numbers of patients with infections for which existing antimicrobial treatments no longer work.”

In addition, Imperial researchers and Corporate Partnerships staff were part of the UK delegation to BioJapan 2017 and 2018, to further the College’s aim to forge new collaborations with partners across the world. Imperial researchers have co-authored more than 1,000 research papers with their Japanese peers in the past five years alone. The delegations have showcased academic — industry collaborations, successful university spinouts, digital health in the NHS and Japan — UK research and commercialisation projects.



EUROPEAN MARKET STRUCTURE RESEARCH NETWORK

Plato Partnership is a not-for-profit company comprised of the largest global equity asset managers and broker dealers. In March 2018, it entered into a strategic partnership with Imperial College Business School to build a network to facilitate independent academic research across the full breadth of the European market structure debate.

Led by Dr Andrei Kirilenko, Director of the Centre for Global Finance and Technology at Imperial College Business School, the network combines academic rigour with institutional knowledge and data from the largest market participants to enable in-depth analysis of consolidated data sets not usually available to academics. It is expected that the innovative research and analysis the Centre is producing around this extremely detailed data will provide the analytical foundation for appropriate market structures in Europe and beyond.

The partnership comes just months after the market faced the largest regulatory overhaul in a decade. “Without a doubt, this is a game-changer for academia, the industry and the regulators,” said Dr Kirilenko.



COMMERCIALISATION

INVENTIVE OUTPUT AND COMMERCIAL DEALS

Invention disclosures, patent applications and commercialisation of IP all contribute to a university’s inventive and economic output.

Managed by Imperial Innovations, invention disclosures at Imperial have increased by 13% this year (page 30), with an increase in the number of patent applications filed, building on the steady growth witnessed over the last six years. The year’s commercial deals were largely dominated by two significant projects in the engineering and medical sectors.



MORE PRECISE ROBOTIC SURGERY

Precision Robotics is working with a range of patented robotic technologies to help surgeons and improve outcomes for patients. It represents a unique partnership between groups in the UK and China, funded by a syndicate of first tier Chinese and Hong-Kong-based investors with sector expertise and commercial and industry resources. Imperial Innovations supported the company from IP protection through to company launch. The Precision Robotics medical robot platform will initially be used for patients requiring colorectal cancer surgery.

Precision Robotics is based on research at Imperial’s Hamlyn Centre for Robotic Surgery led by Professor Guang-Zhong Yang, who discussed some of his technologies with Hong Kong’s Chief Executive Carrie Lam (centre) and Imperial’s President Alice Gast (left) in December 2017.

GROUNDBREAKING GENE THERAPY FOR CYSTIC FIBROSIS

The development of a new lentiviral vector to deliver gene therapy for patients with cystic fibrosis received a significant boost when Imperial Innovations entered an option and licence agreement with Boehringer Ingelheim. The agreement was part of a three-way collaboration between the pharmaceutical company, Oxford BioMedica and the UK Cystic Fibrosis Gene Therapy Consortium, formed by Imperial and the Universities of Edinburgh and Oxford. The collaboration builds on the Consortium’s IP portfolio, takes advantage of the vector’s unique ability to produce high protein levels over long periods, and prepares the route to clinic by establishing robust manufacturing and toxicology programmes.

The Imperial leads for the UK Cystic Fibrosis Gene Therapy Consortium. From left: Professors Uta Griesenbach, Eric Alton and Jane Davies.



NEW ROUTE FOR STARTUPS

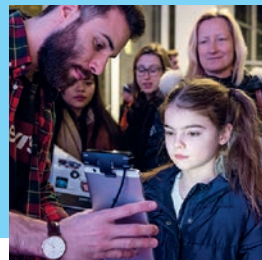
The launch of Founders Choice in August 2017 offered Imperial academics a new route for startups that would secure them up to 95% founding equity in a company based on their research. Imperial Innovations would continue to provide a more basic level of support, including the provision of training, template legal documents and access to professional advisers.

The scheme recognises the knowledge, expertise and strong industry networks of Imperial's entrepreneurial academics (Tables 2 and 3, page 26). Company founders must demonstrate that they have a credible business plan, and have found investors and partners willing to support the venture. Founders Choice represents a significant policy change from the previous route, which continues to provide academics with an option for fuller support and a more even split of equity between founders and Imperial Innovations (which holds founding equity on behalf of the College).

One year into the 18-month pilot phase of Founders Choice, and most new companies formed through Imperial Innovations are now taking the founder-driven route. It is still early days to quantify the full impact of Founders Choice, given the unpredictable timelines involved in forming new

companies, but indications are that the approach is encouraging more startup opportunities, with a boost in startup formation anticipated by the time the pilot comes to an end in January 2019.

"It is gratifying to see that Founders Choice is already proving popular with our academics," says Professor Nick Jennings, Vice-Provost (Research and Enterprise) at Imperial. "Being able to offer a choice on how to set up a business reflects how far our entrepreneurial ecosystem has evolved."



FACIAL RECOGNITION

Dr Stefanos Zafeiriou (Department of Computing) used Founders Choice to set up FaceSoft with plastic surgeon Mr Allan Ponniah from the Royal Free Hospital. FaceSoft uses proprietary machine learning models and databases to improve computer-generated 3D face reconstruction and facial recognition. The technology could be used for treating medical conditions that affect the face, improving biometric security, and as well as refining facial expressions in computer games. The company won the Programm/able competition in 2017, and has since raised investment funding. The Natural History Museum has featured FaceSoft technology as part of its research programme to determine what modern humans would look like as Neanderthals.

SEPARATING MOLECULES

Professor Andrew Livingston (Chemical Engineering) is an established founder of startups, establishing his first Imperial startup in the early '90s, before the College had any formal policy or support for academics in this field. And he was one of the first academics to use Founders Choice for incorporating his latest business venture Exactmer Ltd in December 2017.

"Founders Choice is a great development for academics who know what's needed and just want to get on and set up a company", says Professor Livingston. "It works especially well for those of us who are either confident enough or cheeky enough to think we can handle our own risk."

Professor Livingston enjoys his collaborations with business more generally. He specialises in making membranes that separate molecules, and using those membranes to solve challenges in the oil and gas industry. He says: "Companies have interesting problems and smart people. Collaborating with them has helped me focus my research on challenges that are worth solving."

Exactmer was set up to manufacture and purify high molecular weight polymers. "Establishing a robust process to make it easier for academics to start companies fills an essential niche in any entrepreneurial ecosystem," Livingston observes. "We carry out fundamental research. Then we talk to companies about how it can help solve a problem. And then we set up a company to build the device and deliver the solution."



TESTING GRAPHICS DRIVERS

GraphicsFuzz was set up by Dr Alastair Donaldson (Computing) and colleagues using the Founders Choice route in April 2018 to make graphics drivers more secure and reliable. The company developed innovative automated testing technology that has reduced testing times and improved compliance and security by identifying bugs in flagship devices that cause data theft across browser tabs or device reboots. GraphicsFuzz was acquired by Google in August 2018 and is now open source at github.com/google/graphicsfuzz. Dr Donaldson said: "The acquisition by Google is a fantastic opportunity to maximise the worldwide impact of our graphics driver testing technology."

"Companies have interesting problems and smart people. Collaborating with them has helped me focus my research on challenges that are worth solving."

Professor Livingston

Chemical engineer Professor Andrew Livingston has established several startup companies to develop technologies and devices for improving the separation of molecules for industry.

FROM STARTUP TO SCALEUP

Imperial offers small and medium-sized enterprises (SMEs) a range of opportunities for innovation and growth, including access to student talent, ideas and world-class working spaces and research facilities.

Vital support for early stage businesses

The Imperial White City Incubator lies at the heart of how Imperial supports early stage businesses (Table 7, page 29). Space options include an innovative shared lab that further reduces barriers for smaller up-and-coming startups to get off the ground.

The Incubator has already celebrated a number of 'graduations'. Two companies have moved from the shared lab to their own spaces within the Incubator, including CustoMem. This was set up by Imperial students to develop a new biomaterial to capture and recycle hazardous micropollutants found in industrial wastewater. MiNA Therapeutics, co-founded by Imperial's Professor Nagy Habib to pioneer a new class of medicine called 'small activating RNA', grew rapidly in the Incubator, and have now secured larger facilities elsewhere in the Translation & Innovation Hub (I-HUB).

“Building a deep tech startup requires tremendous effort and more than a shed. The Incubator’s shared labs provided essential access to high grade, excellently located labs at a crucial time in our development.”

Henrik Hagemann, CustoMem CEO (right), with other co-founders

UNDERSTANDING THE NEEDS OF GROWING BUSINESSES

During January – July 2018 Imperial worked with businesses local to Imperial’s White City Campus to understand better the practical challenges that they face, and explore how to help them grow.

The GENERATE pilot programme included interviews with over 250 businesses, alongside a number of sector-based business discovery workshops. The findings are feeding into the College’s ongoing work to shape the new campus so that it responds to the business needs of its local community.

INCUBATOR AT A GLANCE 2017–18

- 19** companies incubated
- 94%** occupancy
- 100+** new jobs created to date
- £85+** million raised by incubator companies to date

New partnership with **RebelBio** the world’s first dedicated life sciences accelerator.

New Experts in Residence Programme for giving incubator tenants access to expert advice and mentoring.

New White City Innovators Programme to provide entrepreneurs and startups with work space and workshops for development.



CONSULTANCY BENEFITS CLIENTS AND ACADEMICS

Business uptake of services including technical advice, testing, analysis and expert witness via Imperial Consultants has continued in the past year, delivering projects for over 400 clients from 29 countries.

In addition to benefits for clients (see case study below), the process of working as a consultant also improves the research practice of academics.

Consultancy projects enable academics to develop a deeper understanding of societal needs, and tailor research to maximise impact and raise their profile: “My consultancy work is leading to more collaboration, more publications and further grant opportunities” confirms Professor Alison Holmes, Department of Medicine.

STORING ENERGY IN DISUSED MINESHAFTS

Alumni-led company Gravitricity commissioned PhD researcher Mr Oliver Schmidt (Centre for Environmental Policy) via Imperial Consultants to provide an independent cost assessment of the technology behind its gravity-fed energy storage system.

The technology stores excess electrical power as potential energy by suspending a weight of up to 2,000 tonnes in disused mineshafts. It uses excess electricity to winch the weight to the top of the shaft for release when energy is required.

“This technology is a first-of-a-kind project,” explains Gravitricity Managing Director Charlie Blair (MSc Environmental Technology 2004), “We wanted to really test the work we had done, so we came back to Imperial.”

“I made sure our study was rigorous and compared all technologies on a level playing field,” Mr Schmidt says. “Gravitricity... comes out looking like a compelling proposition.” The report concluded that the technology could offer cheaper energy storage than batteries and would be particularly well-suited to grid operators.

Alumnus Charlie Blair worked with Imperial Consultants to assess his company’s energy storage technology.



Visit www.imperial-consultants.co.uk to find an academic expert for your business needs.

JOINT PROBLEM SOLVING

Professor Oscar Ces and Drs Nick Jones and Billy Wu – some of the brains behind the Imperial College Advanced Hackspace – explore how a space for invention has a message for everyone.

Using innovation as a route for engaging stakeholders seems like a no-brainer if you work at a university. But if you have no budget, no access to equipment, or your business idea is tangential to your day job, then the process of developing your idea can be quite frustrating.

A few years ago, we asked ourselves what would happen if a university like Imperial gave an equal means of developing ideas to everyone: students, researchers, administrative staff, corporate partners, local businesses and members of the community. Could we activate a dormant population

of inventors, and offer new ways of interacting with the College? Could we even inspire a new generation of entrepreneurs, create new companies, or trigger new avenues of research?

Turning ideas into reality

So it was that in 2014 we established the Imperial College Advanced Hackspace (ICAH). With funding from the Engineering and Physical Sciences Research Council (EPSRC), we set out to provide a community-operated venture with free access to a network of workshops, laboratories, co-location spaces, world-class prototyping equipment, training and experts.

Across its spaces ICAH would support “making” in its broadest sense, from synthetic biology to molecular fabrication, microfluidics, additive manufacturing, robotics and automation, electronics, metal work, woodwork and textiles. All users had

to do was to bring their ideas and pay for their consumables. We would take care of the rest.

Democratic multidisciplinary

In just over four years, the ICAH community has become a multi-disciplinary serendipity machine, convening a community of like-minded hackers, experimentalists, inventors, designers and entrepreneurs from across Imperial.

It’s a place where people with common interests in exploration, device prototyping, med tech, computers, machining, automated synthesis, synthetic biology, digital art, robotic and diagnostics can meet, socialise and collaborate.

It has become a home for democratised research, invention and innovation, where status is irrelevant, and the only thing that counts is your desire to make

things happen and help others in their endeavours. Some people use ICAH to enhance the pace of their research, whilst others want to validate an idea, help solve a business challenge, or generate minimal viable products.

New ways of working with industry

ICAH also has lots to offer new and established businesses that are moving towards more collaborative, leaner innovation models. It is tailor-made for commercial partners to collaborate with College staff, students and alumni to rapidly convert research ideas into breakthrough prototype solutions. It has also become a place where companies come to recruit the brightest minds. If you want to meet global thinkers, change makers, value creators, you will find them at ICAH.

Hackathons provide companies with a specific way to find both ideas and people, by harnessing the ICAH community to develop solutions for defined industrial challenges via a scale-fast, fail-fast framework. At ICAH we convene the best hackers for a brief and organise them into skill-

complementing teams. They come along for the opening night, the company pitches a challenge, and then everyone gets cracking, with ideas being validated and transformed into working prototypes in just days.

Moving forwards

When we established ICAH in 2014, it was an experiment with just two ideation and hackspaces on the South Kensington Campus. In 2017, ICAH extended its capabilities with a new bespoke facility in the Invention Rooms at White City. It is now more closely aligned to Imperial’s wider entrepreneurial ecosystem, with stronger links to the Enterprise Lab and White City Incubator. The ICAH network of spaces is set to grow, as we continue to offer anyone in our networks their ticket to travel from idea to commercialisation.

A version of this article was first published on the EPSRC blog, November 2018.

ICAH ORIGINALS

- **The Polyfloss Factory:** a new recycling process based on the principle of candy-floss machines, to transform thermoplastics into wool for insulation, packaging, garments or product design.
- **Supersilk:** feeding graphene to silk worms creates a new, strong, conductive, sustainable material that could be woven into maternity clothing to incorporate sensors for monitoring blood pressure and baby movements.
- **Bladebug:** a multi-legged, walking robot for maintaining wind turbine blades, maximising their lifespan and reducing the need for humans to undertake risky abseiling inspections.
- **3D printed ceramics:** a new ceramic printer creates intricate 3D internal structures and surface patterns that can be used to alter the mechanical properties of materials.
- **Gyrogear:** an Imperial startup company developing a device to stabilise the hands of people with tremors developed its first prototypes in ICAH.

Imperial’s Advanced Hackspace provides extensive prototyping equipment for the College’s community of makers, hackers, inventors, entrepreneurs and business collaborators.



FAST-TRACKING POSTDOC BUSINESS IDEAS

In the past year, Imperial has launched two accelerator programmes for early career researchers, to provide this highly skilled community with thinking time for exploring the commercial potential of their work.

First up was the College's pilot Techcelerate programme, launched in January 2018. This offered fourteen postdocs the chance to immerse themselves in a three-month programme of entrepreneurship training to explore the market pull of their business ideas.

Then in June 2018, an Imperial-led consortium launched the MedTech SuperConnector (MTSC) entrepreneurship programme, with £5 million funding from the Research England Connecting Capability Fund to boost the commercialisation of new medical technologies. The first MTSC cohort comprises ten early career researchers from seven higher education institutions, with four from Imperial.

Both schemes buy time out of the lab for participants, and immerse them in entrepreneurship training, with access to incubator, accelerator and industry networks, alongside consumable and travel allowances. Evaluation of Techcelerate cohort one shows that

market awareness was enhanced, with market opportunities confirmed in some cases, in line with the programme's objectives.

"These schemes upskill our postdocs by helping them develop a nuanced understanding of what their potential customers want, at a time when many researchers are thinking about next steps in their careers," says Ben Mumby-Croft, Director of Imperial's Enterprise Lab. "Feedback suggests that we are providing essential support to this traditionally underserved, yet highly talented, part of the College's entrepreneurial ecosystem. Ultimately both academic and business communities stand to benefit."



AI FOR ENGINEERS

Dr Richard Ahlfeld (Aeronautics) used Techcelerate to explore the value of AI software for applying machine learning to engineering. He has since secured a pilot project with Airbus, several grants and office space for his company UQuant Ltd, which now has seven part-time staff. "I always thought I would be an academic and an entrepreneur on the side. Instead I am now an entrepreneur and an academic on the side."



EXOSOMES AS NANO-THERAPEUTICS

Finding better ways of capturing and isolating tiny cellular messages known as exosomes, and using them as therapeutics to help treat cancer, is the foundation of Envoy Biosciences, the company being set up by Dr Richard Kelwick (Medicine). "The Techcelerate programme was career-changing for me. I now have a strong foundation from which to explore potential translational opportunities."



SEPARATING BIOMASS

Finding a way to split biomass into its three main polymer components could help replace oil with renewable biological resources. Dr Florence Gschwend (Chemical Engineering) used Techcelerate to develop Chrysalix Technologies – the startup she co-founded to commercialise the biomass separation process. "It's an excellent programme if you have little or no entrepreneurship experience."



MORE FLEXIBLE BATTERIES

Finding a better way for batteries to match the variability of wind and solar power with peaks and troughs in energy demand is what drives the work of Dr Vladimir Yufit (Earth Science and Engineering). Thanks to Techcelerate and subsequent grants, he has set up a new company, RFC Power Limited, through Founders Choice (see pages 8-9): "Techcelerate changed the way I viewed the technology, as a system that's flexible and can be tailored to the customer."

Read more about Techcelerate cohort one and meet cohort two at www.imperial.ac.uk/enterprise/techcelerate

A HOME FOR BUSINESS

Imperial's White City Campus houses a rapidly expanding entrepreneurial ecosystem. It provides a home for local entrepreneurs, world-leading academics, strategic industrial partners, talented students, and more than 70 companies ranging from startups to corporates.

Scale up: the next wave of high-growth, high-tech digital companies ready to scale their businesses will find a home in **Scale Space** – a collaboration between venture builder Blenheim Chalcot and Imperial.

Co-location: Businesses looking to work alongside entrepreneurs and world-class researchers to turn innovations into new products and services will find a home in the **Translation & Innovation Hub (I-HUB)**. Operated by **Imperial College ThinkSpace**, I-HUB supports startups and fast-growth companies, established scientific research organisations, and accelerator programmes. It includes **Central Working** – the co-working space for West London's enterprise community.

The Invention Rooms: These offer spaces for businesses, Imperial staff and students, and the local community to collaborate. Designed to inspire inventors, entrepreneurs and makers, the building includes the **Imperial College Advanced Hackspace** (page 14).

Engineering solutions: Currently under construction, the **Michael Uren Biomedical Engineering Research Hub** will complete in 2019, bringing 600 engineers, scientists and clinicians together in this unique space to address pressing healthcare challenges.

Better chemistry: With state-of-the-art spaces for companies to collaborate with researchers to address global challenges such as energy, healthcare and sustainability, the **Molecular Sciences Research Hub** also provides a new research home for Imperial's Department of Chemistry.

Incubation: Early-stage science companies can find office and laboratory space, mentoring and support in the **White City Incubator** (page 12). This provides office, laboratory space and support for early-stage science companies.

Residential tower: From 2019, **Eighty Eight Wood Lane** will provide 192 new homes, offering people an opportunity to live in the heart of this pioneering neighbourhood. The building includes 59 flats at affordable rent for Imperial key workers.

Improving health: A state-of-the-art hub to house Imperial's **School of Public Health** has entered an exciting phase, with a £100 million fundraising campaign to support the development of this new space for health, wellbeing research, education and community engagement.

On-site talent: Imperial's White City community includes 600 Imperial postgraduate students who live on campus in the **Wood Lane Studios**.

A PLATFORM FOR INNOVATION

10 hectares

£2b investment in our White City Campus

£85+m raised by incubator companies to date

1,300 scientists, clinicians and engineers on campus by the end of 2019

Student startups are an increasingly important part of Imperial's enterprising activity, and their success is reflected by some striking headline statistics.

ENTERPRISING STUDENTS

In 2017–18, a record 41 student startups were incorporated, 180 new jobs were created, and over £17m investment was received. The three-year survival rate for companies founded by Imperial students is 81% compared to a London average of just over 50%. Notable student startup awards are listed in Table 5 (page 27).

Professor David Gann, Imperial's Vice President for Innovation, attributes this success in large part to the College's combined strength in STEM and business – not only the education and research training it offers, but also the expanding activity on-campus to motivate and support student entrepreneurship.

The Enterprise Lab, launched in 2016, is the College's hub for student entrepreneurship, offering work space, facilities, advice and mentoring. "Students who go through the Lab have a fantastic opportunity to hone their concept from a technical point of view, and learn what it takes to develop a business around that idea", says Professor Gann.

The Lab is home to the College's flagship student entrepreneurship support programmes, which help students develop business ideas through masterclasses and coaching, culminating in showcases in which

finalists are invited to bid for a share of a prize fund. In the last year, the WE Innovate and the Venture Catalyst Challenge (VCC) grew substantially in scale and ambition.

WE Innovate, which is dedicated to women-led startups, expanded with support from Santander Universities and the Swarovski Foundation. In 2017–18, it supported 68 women (up from 40 the year before) from a pool of 210 applicants. Its first prize, increased to £15,000, was awarded to life sciences undergraduate Saujanya Vruddhula for her venture Oggic, which is developing technology to prevent the counterfeiting of drugs.

With support from sponsor Blenheim Chalcot, VCC doubled its prize fund to £40,000, awarding a first prize of £20,000 to maternal health venture Momoby, and supported more teams than ever before. Dr Ana Luisa Neves, Momoby's co-founder, said "VCC provided us with the strategic skills to engage with technology partners, clients and most importantly, the confidence to promote it and share our passion about maternal health with other stakeholders."

Continues on page 22 →

Drs Andrea Rodriguez Martinez (L) and Ana Luisa Neves set up Momoby to improve access to healthcare for pregnant women living in isolated areas.



MOMOBY

Momoby is developing an easy-to-use finger prick test that pregnant women can use to test for diseases known to impact on pregnancy. It aims to improve the health of mothers and babies in low-income countries, where access to prenatal care can be limited. The venture was launched in 2016 while co-founders Dr Ana Luisa Neves and Dr Andrea Rodriguez-Martinez were still completing PhDs (Department of Surgery and Cancer). The pair won second prize in WE Innovate 2016–17, and went on to win the first prize in VCC 2018 and third prize in the IDea Incubator at IDWeek 2018, a prestigious conference focusing on infectious diseases. They are now seeking further investment to validate their prototype.

STUDENT INNOVATORS

Enterprising students continued

The Enterprise Lab has been growing as not only a resource but also a community. Dr Evgeniy Donchev was awarded a PhD in Materials from Imperial in 2015 and, as an alumnus, continues to use the Lab to support his non-volatile memory startup, LoMaRe Technologies.

He says: "The Lab wasn't very well known in the beginning, but now it has really expanded. I use it regularly to work on my company, surrounded by people with like-minded goals, which motivates me even more. The Lab team is amazing – a perfect blend of skilled individuals who are interested in getting to know what you're doing, giving you advice and motivating you. There is definitely a community – the first time you meet everyone you're already part of the family."

While the Enterprise Lab is the College's main hub for entrepreneurial students, it is not the final destination, but an entry point into Imperial's wider entrepreneurial ecosystem, including the redeveloped workshop and prototyping facilities at Advanced Hackspace, and the incubator facilities in the Translation & Innovation Hub (I-HUB). For the first time, student startups launched in the Enterprise Lab are progressing to the White City Incubator, and could soon progress to leasing their own spaces in the I-HUB building.

Professor Gann says: "When you see that pathway of opportunity, it matches what Imperial wanted to do and has done at White City, which is create the spaces for companies to start to be mentored and incubate, and then expand, without having to leave the district, so they're very close to the mothership – and I think that's really important."

Find out more:
www.imperialenterpriselab.com

OGGIC

Oggic is the brainchild of Saujanya Vruddhula, an undergraduate from the Department of Life Sciences. The venture aims to prevent counterfeit drugs entering the market by using QR codes printed not just on the packaging, but on the drugs, which are registered incorruptibly using blockchain. This could help reduce the 300,000 to 500,000 lives lost to each year due to counterfeit drugs. Saujanya was awarded the £15,000 first prize in WE Innovate 2017–18 and hopes to use it to launch the product in the near future. She said: "I joined the programme with no real idea of what I wanted my business to be. With the support of the Enterprise Lab, I've created a business which could save both lives and vast amounts of money for industry."



THINAIR

ThinAir is developing a technology to extract clean water from the air efficiently. It is intended to help in humanitarian emergencies and locations where drinking water may otherwise be in short supply, and will initially be brought to market for the purpose of optimising dehumidifiers. Since taking the venture to the final of VCC 2017, the co-founders, led by CEO Jonathan Risley, have completed undergraduate degrees at Imperial and taken up space in the I-HUB, both in the White City Incubator and Central Working. They have won a series of prizes, and were finalists in the prestigious XPRIZE competition that aims to alleviate the global water crisis. They are currently optimising the technology in readiness for commercialisation.



IMPERIAL VENTURE MENTORING SERVICE



From left: Mohit Devgan and Pashiini Supramanian from student startup QuickCount meet IVMS mentors Dominique Klein and Paul Dowling.

BUSINESS LEADERS AS MENTORS

The Imperial Venture Mentoring Service (IVMS) was launched in September 2017 to provide College staff and student entrepreneurs with unbiased and expert advice on realising their business idea by developing a startup company.

In its first year, the scheme has recruited 34 high-profile, successful entrepreneurs and investors as mentors, most of whom are actively employed. They have worked on a pro-bono basis with 14 ventures that have pitched at the monthly mentor meetings to be matched with their mentors for impartial business advice.

Modelled on the MIT Venture Mentoring Service, the Imperial scheme has been set up to secure high standards of participation from ventures and mentors alike, and is closely aligned to the academic mission of the College, by supporting the translation of ideas into benefits for society.

Ideal applicants in the first year of IVMS have been those that have already shaped their initial business idea by participating in one of the College's core entrepreneurship programmes, such as Venture Catalyst Challenge, WE Innovate, or Techcelerate.

IVMS progress is being tracked in several ways, including broad performance measures of the ventures, as well as satisfaction of mentors and mentees, retention and growth of the mentor pool, and scale of interest from prospective mentees.

"I personally was attracted to the idea of helping highly trained and talented people founding technology startups out of a world class institution", says serial entrepreneur Dr Paul Atherton (Physics 1978), who was instrumental in setting up IVMS, and now directs the scheme. "We are here to help everyone who has the energy and guts to try, from the established professor to the first year student. We have got off to a flying start and I am very excited about the level of interest from prospective mentors and the flow of amazing new ideas coming through."

Go to www.imperial.ac.uk/enterprise/ivms to find out more about becoming an IVMS mentor.

IVMS IN
NUMBERS
2017–18

34
high profile mentors
recruited

70+
mentoring hours
have taken place

14
active ventures
receiving mentoring

1
venture graduated
from IVMS

£1m+
private funding raised
since January 2018

5
competitions won,
with prize funding
and support worth
over £500,000

2
ventures have
taken up office and
laboratory space in
the Imperial White
City Incubator

A YEAR OF ENTERPRISING ACTIVITY: 2017–2018

TABLE 1: STUDENT STARTUPS* FORMED 2017–18

Startup	Concept
BASIC MATERIALS	
Finite	A material developed from desert sand with similar structural properties to concrete but less than half the carbon footprint.
Tagless	A protective anti-graffiti coating that can be applied to a range of surfaces. It also protects vulnerable buildings from weathering erosion.
CONSUMER	
Emit	A time-management tool that shows people the amount of time left before their next commitment rather than time as an absolute value.
Knightsbridge Tutors	Knightsbridge Tutors offers a range of tuition services to make learning fun and productive for school children.
EDUCATION	
Bawer Services	Bawer Services provides educational, engagement and research services, with expertise in diversity and inclusion.
ENERGY	
Progress Energy Consulting	Management consulting services for the energy industry.
FINANCIAL SERVICES	
ApTap	This app connects users with their banks and service providers to retrieve bills and manage payments and services with a single tap.
OsusuMobile	OsusuMobile helps the unbanked and the underbanked save money by making deposits with an SMS-enabled mobile phone.
Quanterium Technologies	Quanterium Technologies is developing a fully regulated digital asset trading platform, incorporating elements of Blockchain technology.
TRACK	An AI-driven tool to help homebuyers make complicated financial decisions more easily and transparently.
FOOD & NUTRITION	
BioKind	BioKind ferments agricultural waste to produce sustainable and traceable protein feed for aquaculture, livestock and pets.
Higher Steaks	Higher Steaks uses cell culture techniques to produce lab-grown meat quickly and affordably using a scalable process.
Mela	Mela is a service company that provides chocolate bonbons with a bacterial cocktail specially designed to improve your wellbeing.
Nutribloc	Nutribloc is a plant protein-based block of powder that dissolves in a liquid to create a healthy drink or boost a smoothie.
INDUSTRIALS	
Matoha Ultrascience	This company has developed a scanner to identify accurately and rapidly what polymer a piece of plastic is made from, so it can be sorted for further processing.
MEDICAL DEVICES	
Gilaasi	Gilaasi is working on a patent-pending innovation that enables users to switch from glasses to sunglasses with just a tap of the frame.
Microsonix	Microsonix is working to bring life-saving medical imaging to more people in developing countries with a miniature, low-cost ultrasound imaging device that connects to a smartphone.
Mitt	Mitt is developing an accessible, comfortable, plug-and-play prosthesis to help people suffering from limb loss.
Momoby	Momoby has developed an innovative finger prick test to bring antenatal care to women living in geographically isolated areas.
Motus Innovations	A new generation of low cost robotic rehabilitation devices to make rehabilitation technologies more accessible to those who need them most.

Startup	Concept
MEDICAL DEVICES	
Neuroloom	Neuroloom has developed high resolution brain-machine interfaces, with their first application in restoring sight for people with conditions such as macular degeneration.
QuickCount	A low-cost, hand-held device for point-of-care blood analysis.
PHARMA & BIOTECH	
Naturacorp	Genetically engineered, dirt-eating bacteria to reduce the use of carcinogens in the dry cleaning industry.
Vigor	A glove that provides extra strength to children with muscular dystrophy, mild cerebral palsy or related neuromuscular diseases.
TECHNOLOGY	
BlakBear	Innovative sensor technologies for measuring air quality, and applications for food packaging and agriculture.
BlockClaim	BlockClaim is combining AI and blockchain to improve detection of fraudulent claims and reduce claims processing time in the motor insurance sector.
Boetho	Boetho has developed a machine learning based algorithm to predict demand for and optimise occupancy of parking spaces.
Deep Render	Deep Render is developing machine learning and computer vision algorithms with applications for compression and rendering systems.
Donaco	Donaco facilitates online donations by using AI to place calls for donations from readers next to relevant online articles.
Drip	Drip has developed a cobot to dispense shots and basic mixers in nightclubs by pouring eight drinks per minute.
Dyne London	This app increases table turnover for exclusive restaurants by offering users the chance to occupy cancelled/no-show tables within 20 minutes.
Elemental	Elemental is based on the game mechanics of Pokemon to build an educational game for students to learn about chemistry.
InAGlobe Education	This organisation connects problems identified by NGOs in developing countries with students in technical universities who work on solutions as part of their degree.
Lekta Therapy	An online therapy platform for improving mental health.
Loop Party	A social event organisation app for people to plan meetups, covering everything from invites to cost-splitting, music and clean-up.
NeuroCreate	A personal interactive, AI-powered platform with a suite of digital tools to help people become more efficient and productive.
Pepar	This app suggests recipes based on available ingredients from users nearby, encouraging the creative and social use of high-risk food.
Phenomic AI	Phenomic AI is developing deep learning solutions to accelerate drug discovery.
TELECOMS	
Meetual	Meetual has developed a mobile application that lets users connect their friends with each other.
TRAVEL & LEISURE	
Balentify Events	Balentify events provides conference, exhibition, fair and event services in London.
For The Love of The Game	For The Love Of The Game identifies opportunities to play sports in competitive, social leagues across London.

*Companies founded to exploit IP from ideas or discoveries made by Imperial students during their degree courses.

TABLE 2: IP STARTUPS* FORMED 2017–18

Startup	Concept
BASIC MATERIALS	
Exactmer	A new technology platform – Nanostar Sieving – to produce high molecular weight polymers of outstanding purity.
ENERGY	
RFC Power	New technologies for mitigating issues linked to the cost and limited availability of the raw materials needed for batteries. RFC Power’s unique technology combines optimised cell architecture and low-cost chemistry in a hybrid gas-liquid redox flow battery.
INDUSTRIALS	
Tribosim	A tribology simulation and consultancy business.
MEDICAL DEVICES	
Accunea	Medical device and novel point-of-care diagnostic to provide real-time monitoring of kidney function.
CEEK Health	Ear examination kit.
Precision Robotics	Medical robots have been developed to conduct colorectal oncology surgeries. The platform will be expandable for other surgeries including oral and gynaecological.
VODCA	Early cancer detection by breath testing.
PHARMA & BIOTECH	
Cagen	Cagen has developed self-assembling protein nanocages that can be used to transport and deliver drugs within the body, protecting them from premature degradation.
TECHNOLOGY	
FaceSoft	Proprietary machine learning models and databases to improve computer-generated 3D face reconstruction and facial recognition.
GraphicsFuzz	Specialise in mobile graphics benchmarking tools, including the detection of vulnerabilities in graphics drivers, enabling clients to quickly find and fix bugs that could undermine reliability and security before they affect end users.

*Companies founded to exploit IP owned by Imperial, typically led by academic staff who made the initial discovery. Based on licence of College IP into the company.

TABLE 3: PROGRESS OF IMPERIAL STARTUPS 2017–18

Criteria	IP startups	Student startups	Total
Number of active startups (as of 31st July 2018)	79	122	201
Number of listed startups (as of 31st July 2018)	5	0	5
Number of startups acquired by third parties (since 2000)	24	6	30
Investment funds secured in 2017–18 (£m)	87.5	17.6	105.1

TABLE 4: NOTABLE INVESTMENT ROUNDS FOR IMPERIAL STARTUPS 2017–18*

Startup	Amount raised (£M)	Context
BASIC MATERIALS		
Biomin	0.4	Raised via an internal round.
Microtech Ceramics	1.25	Develops novel ceramic substrates for the automotive emissions control market, closed a £1.25m investment deal.
ENERGY		
Bramble Energy	0.6	Bramble Energy is an Imperial / University College London startup that has developed a unique, patent-protected, printed circuit board fuel cell. This utilises cost-effective production methods and materials to reduce the cost and complexity of manufacturing of proton exchange membrane fuel cells. It has recently raised £600,000 from three investors.
TECHNOLOGY		
FaceSoft	0.46	FaceSoft uses machine learning models for 3D face reconstruction and facial recognition. The team has trained its face reconstruction algorithm parameters using a proprietary database of 2.5 million high-resolution 3D scans of real faces. The trained reconstruction model enables FaceSoft to create billions of realistic computer-generated faces, far surpassing any existing database of real faces. It completed a £150,000 Seed Enterprise Investment Scheme investment.

*Based on publicly announced information.

TABLE 5: NOTABLE STUDENT STARTUP SUCCESSES 2017–18

Startup	Prize / award	Context
FOOD & NUTRITION		
Skipping Rocks Lab	Undisclosed	Sky Ocean Ventures invested in Skipping Rocks Lab edible sachet Ooho.
INDUSTRIALS		
CustoMem	£1.2 million	Secured Horizon 2020 funding to bring its innovative water filtration system to market.
MEDICAL DEVICES		
GyroGear	£1.6 million	Secured Horizon 2020 SME instrument funding, to support development of its stabilising GyroGlove for patients with hand tremors.
Neuroloom	£100,000	Won the 2018 Panacea Stars Accelerators award.
PERSONAL CARE		
Polipop (formerly WithLula)	£20,000	Won The 2018 London Mayor’s Entrepreneur Competition.
TECHNOLOGY		
Gravity Sketch	£1.2 million	Raised from Forward Partners (London) and Super Ventures (San Francisco).
Phenomic AI	£1.2 million	Raised from US investors.
Quit Genius	£1.5 million	Won a 2018 Pitch@Palace People’s Choice award. Finished Y Combinator and raised £1.5 million seed round from angel investors.

TABLE 6: NOTABLE MARKET ACTIVITY FOR IP STARTUPS 2017–18

Startup	Context
ENERGY	
Nexeon	Nexeon develops silicon materials for next generation Li-ion batteries. In early 2018 it was awarded £7 million in Innovate UK funding to develop significantly better materials for Li-ion batteries.
FOOD & NUTRITION	
Skipping Rocks Lab	Ooho! - the edible, biodegradable packaging developed by Skipping Rocks Lab - is now being used by Selfridges as part of the department store's work to eliminate single-use plastic bottles from its shelves and reduce overall plastic pollution. The Skipping Rocks Lab team also received investment from Sky Ocean Ventures.
MEDICAL DEVICES	
EMcision	EMcision - the company that developed the Habib™ EndoHPB probe - was acquired by global medical technology leader Boston Scientific. The probe is used by physicians in the treatment and palliative care of patients living with pancreaticobiliary cancers, which account for nearly a million deaths each year and have limited treatment options.
TECHNOLOGY	
GraphicsFuzz	GraphicsFuzz specialises in mobile graphics benchmarking tools. In August 2018 it was acquired by Google.

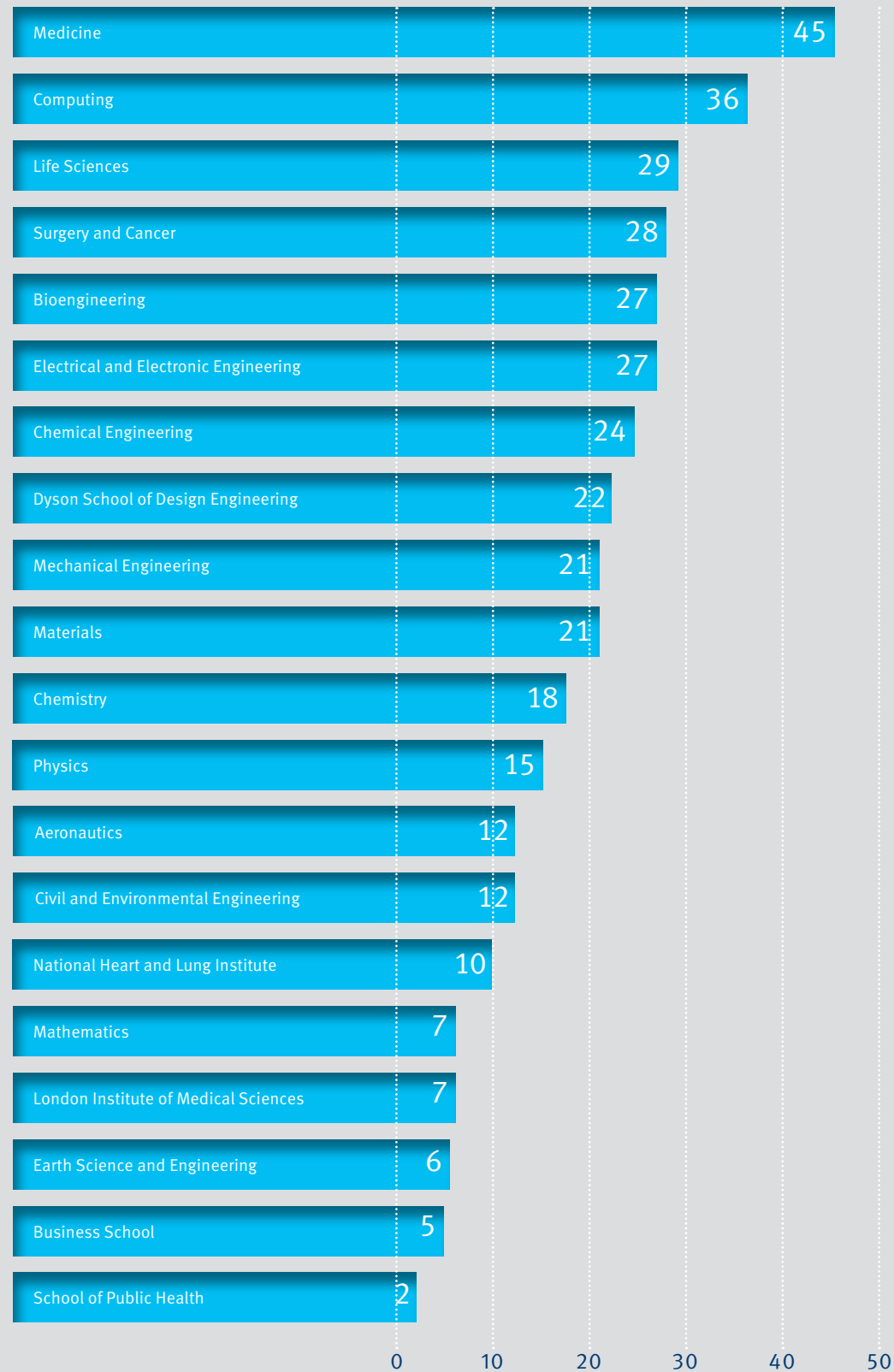
TABLE 7: STARTUPS IN THE WHITE CITY INCUBATOR AS OF JULY 2018

Startup	Context
BASIC MATERIALS	
Polymateria	Biodegradable, recyclable, customisable and cost-effective plastics.
ENERGY	
SMAP Energy	Smart energy meter data to accelerate the adoption of Energy AI.
SweetGen	Creating energy from waste water with innovative catalyst technology.
INDUSTRIALS	
CustoMem	Targeted filtering technology for micropollutants.
HackScience (now Cytera)	Harnessing the Internet of Things and web technologies to accelerate scientific research by enabling scientists to create and share affordable lab tools to automate manual processes.
Hexxcell*	Thermo-hydraulic fouling predictions for heat exchangers.
MEDICAL DEVICES	
MediSieve	Drug-free malaria treatment using magnetic blood filtration.
Smart Respiratory	Smart peak flow meter and app for helping asthma patients track their lung function.
PHARMA & BIOTECH	
Affinity Laboratories	Diagnostics and therapeutics through biomarker discovery.
Autolus Ltd	Developing novel immunotherapies for oncology.
Axitan	Veterinary vaccines and peptides from microalgae.
FreshCheck	Quick confirmation of bacterial contamination.
GammaDelta Therapeutics	Harnessing gamma delta T cells to improve immunotherapy for diseases including cancer.
MiNA Therapeutics	Gene activation mechanisms through small activating RNA.
Pulmocide*	Inhaled anti-infectives for targeted treatment of life-threatening lung infections.
Senzer	Adjuvant therapies to help alleviate the side effects of cancer and chronic pain.
ThinAir	Bringing water to water-scarce communities across the globe.
TECHNOLOGY	
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 Chronic Obstructive Pulmonary Disease.

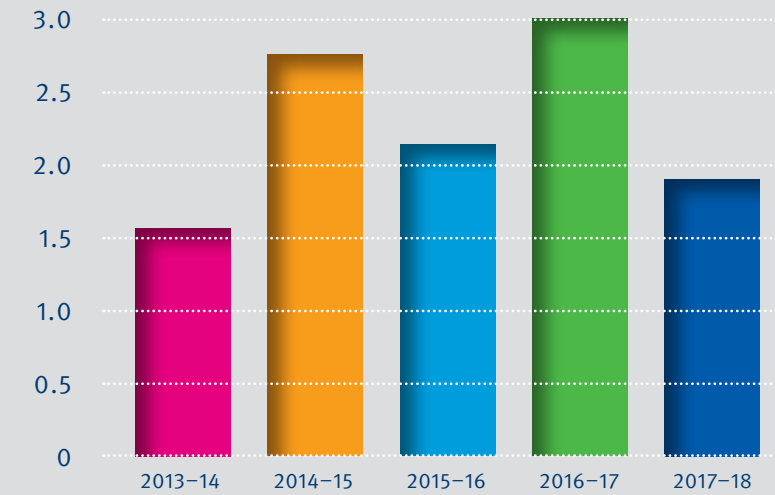
* indicates an affiliation with Imperial through IP

ENTERPRISING ACTIVITY DATA 2017-18

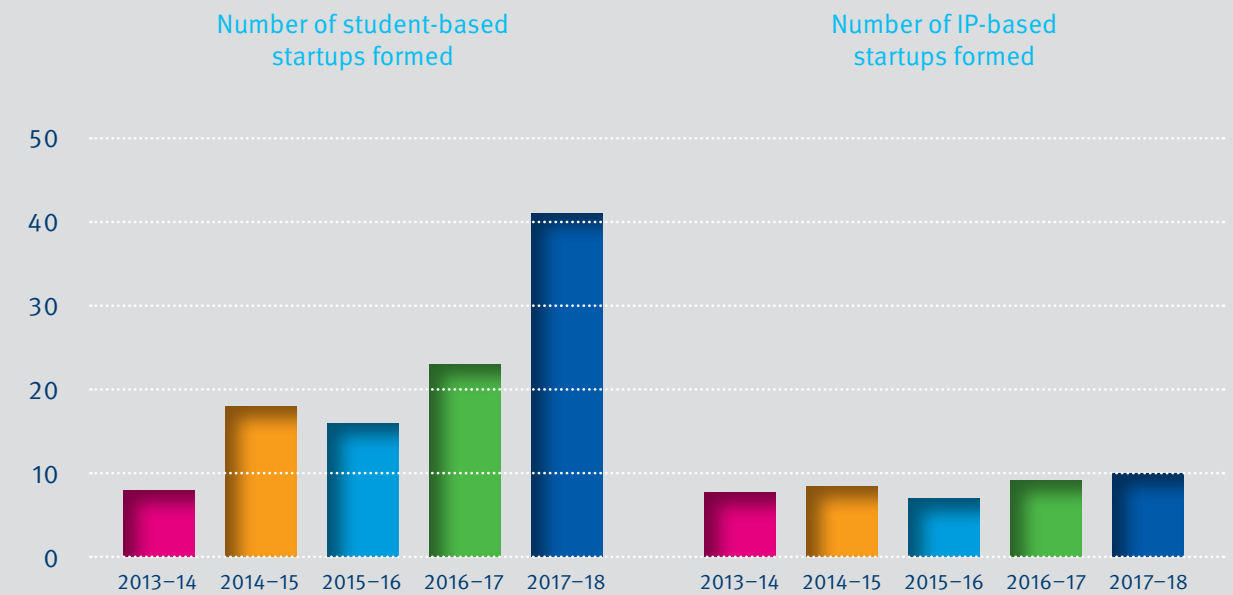
DISTRIBUTION OF INVENTION DISCLOSURES BY ACADEMIC DEPARTMENT AT IMPERIAL



LICENSING REVENUE (£M) AT IMPERIAL COLLEGE LONDON 2013-18



NUMBER OF IP AND STUDENT STARTUPS FORMED AT IMPERIAL 2013-18



NOTABLE TRENDS

1. Corporate partnerships

The bulk of awards still come from Pharma and Biotech companies (25% of project count). Energy (22%), Industrials (14%) and Technology companies (9%) have overtaken Aerospace & Defence.

Awards from Healthcare Providers punch above their weight with £1.14 million in funding across eight projects. Funding from Medical Device companies was also strong with £1.4 million across 28 projects.

Financial Services companies invested £2.4 million across 23 projects, equating to 4.7% of the total income.

The vast majority of our industry partners fall within the wider manufacturing domain (pharma, basic chemicals, turbine engines and aircraft) and Mining / Oil and Gas, with a significant contribution from ICT companies (majority Wireless telecommunications).

2. Inventive output

Invention disclosures have increased by 13% this year. Patent applications filed have also increased, following the steady growth over the last six years.

3. Licensing

The number of new licence agreements signed has stayed steady, along with the cumulative number of active licences held - around 200 over the last four years. Royalty fee income has reduced from £3 million to £1.9 million (the five year average for this figure is £2.3 million). The 2016-17 figure included a large lump licence payment from a notable company exit, making up the majority of the difference.

4. Startups

Startups created: There has been a 178% increase in the number of student startups incorporated, compared with last year. This significant upward trend is driven primarily by post-programme support (in particular, via the Imperial

Venture Mentoring Service, business coaching workshops and access to the London ecosystem) and by more sophisticated Enterprise Lab programming (such as the new Venture Catalyst Challenge programme content).

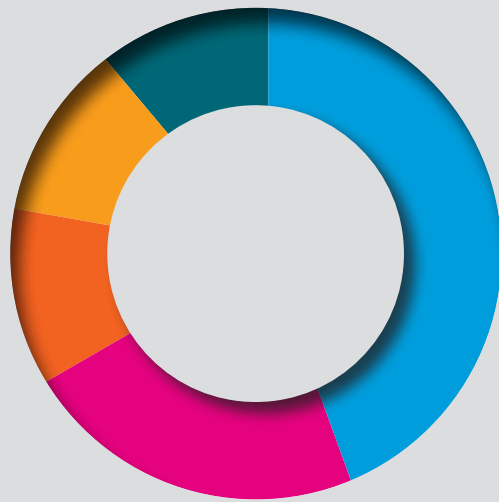
Funding: There has been a large increase in funding for startups (as per the scorecard, inside back cover) - primarily down to some more mature companies raising larger funding rounds, including SAM Labs, CustoMem and Gravity Sketch.

Survival rate: A higher number of companies survive the first 12 months of incorporation as a result of the increased level of support offered to post-incorporated companies. Three year survival rate of student startups is currently at 81% compared to the London average of 50.1%.

5. Consulting

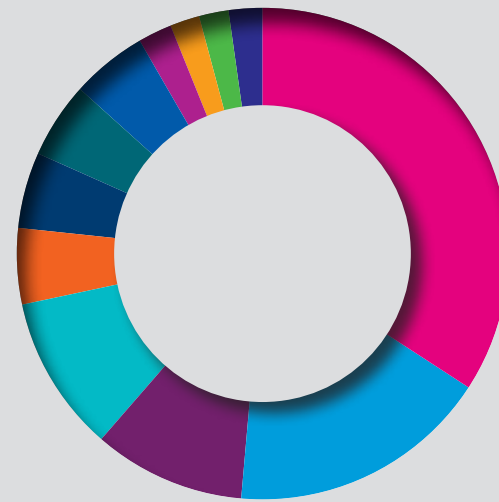
There has been a 4% rise in the number of new projects via Imperial Consultants, a 6% rise in number of clients and a continuing trend of increase in new consultants leading projects with a 13% increase on last year.

IP STARTUPS FORMED IN 2017-18 BY SECTOR



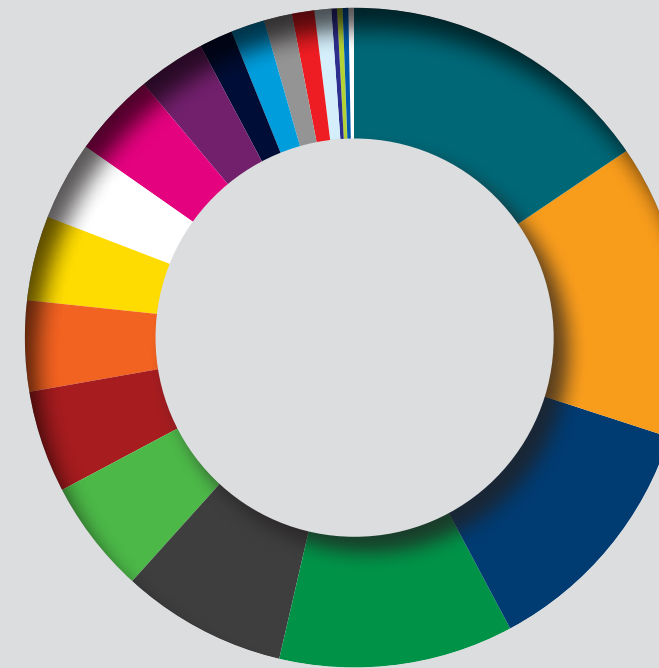
Medical Devices	44%
Technology	22%
Basic Materials	11%
Energy	11%
Pharma & Biotech	11%

STUDENT STARTUPS FORMED IN 2017-18 BY SECTOR



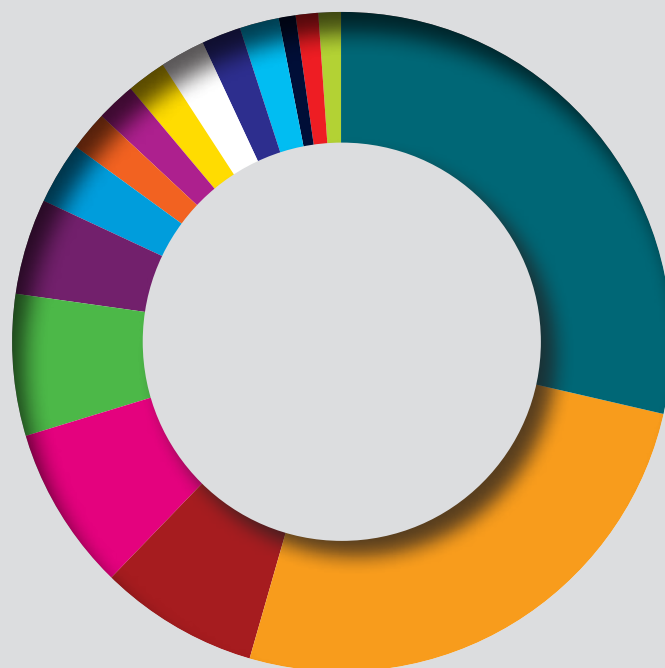
Technology	34%
Medical Devices	17%
Pharma & Biotech	5%
Travel & Leisure	5%
Financial Services	10%
Consumer	2%
Food & Nutrition	10%
Energy	2%
Basic Materials	5%
Industrials	2%
Education	5%
Telecoms	2%

IMPERIAL CONSULTANTS PROJECTS BY SECTOR 2017-18



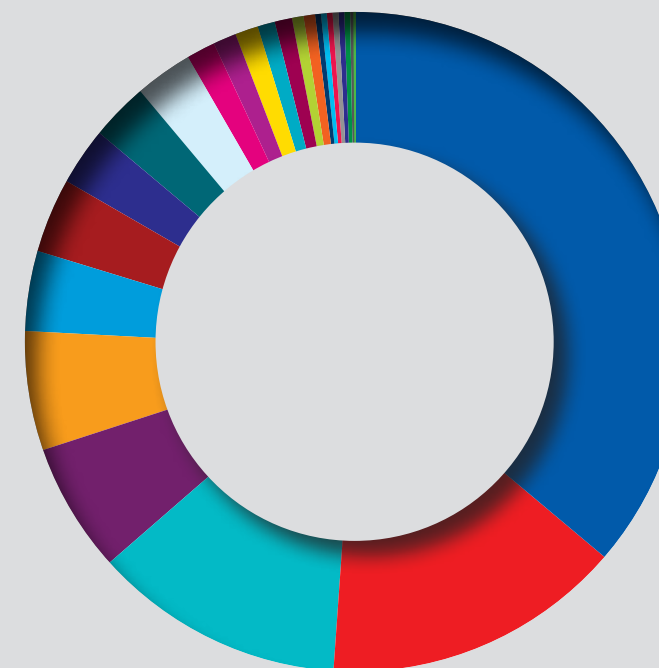
Pharma & Biotech	59	15.6%
Energy	55	14.5%
Education	47	12.4%
Professional Services	43	11.3%
Infrastructure	31	8.2%
Industrials	21	5.5%
Aerospace & Defence	19	5.0%
Basic Materials	17	4.5%
Healthcare Providers	15	4.0%
Other	15	4.0%
Technology	15	4.0%
Financial Services	13	3.4%
Automotive	7	1.8%
Medical Devices	6	1.6%
Sports & Leisure	5	1.3%
Food & Nutrition	4	1.1%
Media	3	0.8%
Telecoms	2	0.5%
Personal Care	1	0.3%
Travel & Leisure	1	0.3%
TOTAL	379	100.0%

INDUSTRY INCOME IN 2017-18 BY SECTOR



Pharma & Biotech	29%
Energy	26%
Aerospace & Defence	8%
Technology	8%
Industrials	7%
Financial Services	5%
Medical Devices	3%
Basic Materials	2%
Consumer	2%
Healthcare Providers	2%
Other	2%
Telecoms	2%
Utilities	2%
Automotive	1%
Food & Nutrition	1%
Personal Care	1%

RESEARCH INCOME FROM INDUSTRY BY COUNTRY OF HEADQUARTER 2017-18



UK	36.3%
US	14.8%
Netherlands	12.5%
Qatar	6.5%
China	5.8%
France	3.8%
Switzerland	3.5%
Belgium	3.0%
Germany	2.7%
Japan	2.6%
Denmark	1.6%
Malaysia	1.1%
Sweden	1.1%
Korea	0.8%
Israel	0.7%
Norway	0.7%
UAE	0.3%
Brazil	0.3%
Finland	0.3%
Italy	0.3%
Spain	0.3%
Canada	0.2%
Iceland	0.2%
South Korea	0.1%
Australia	0.1%

DIRECTOR'S LETTER

It is a pleasure to report that in the past year we have launched schemes to support three key parts of our community:

- Any Imperial innovator with a business idea can now pitch for support from a team of high-profile mentors working for the Imperial Venture Monitoring Service.
- Entrepreneurial early career researchers can now apply for support and training from our Techcelerate programme, and the MedTech SuperConnector.
- Academics can now secure up to 95% equity of a startup company based on their research through Founders Choice.

These schemes are delivering promising new technologies, from wireless charged drones to low cost sensing of sepsis.

Our research collaborations with corporate partners continue to grow. It is pleasing to see the launch of novel modes of engagement such as the Agilent Measurement Suite, and exciting new projects from long-term partners such as ABB and AstraZeneca, and new partners such as the Plato Partnership.

We also welcome new modes of engagement with business, such as the Airports Benchmarking Group in the Railway and Transport Strategy Centre, which helps airports around the world to establish best practice and improve performance.

One of the most gratifying developments on the White City Campus has been the College's first shared wet-lab incubator space. Created in response to requests from new startups for smaller spaces and shared equipment to keep costs down,

it attracted nine companies in its first year, two of which have already graduated to take up larger labs in the Incubator. This represents exciting evidence of our ecosystem's ability to create growth and jobs in biotech and clean tech sectors.

Taking a group of ten student entrepreneurs from our Enterprise Lab as part of Imperial's delegation to the World Economic Forum in Tianjin in September 2018 was a significant move in our work to grow collaborations with China and internationalise the support we provide our student entrepreneurs. We look forward to expanding this work in the year ahead, including exploring the concept of global co-founders for our student startups.

Optimising our entrepreneurial ecosystem challenges us to review practices within College. We continue to explore how we can work more effectively with partner communities, such as investors or entrepreneurial alumni, to engage you on a regular basis with Imperial's entrepreneurial ideas, students and academics.

Offering clearer ways for you to navigate our sometimes complex organisation is a priority for the year ahead. I welcome any suggestions for how we can work together to match Imperial enterprising activity with a corresponding scale and diversity of collaboration and support.

Dr Simon Hepworth, Director of Enterprise, Imperial College London

ENTERPRISING ACTIVITY SCORECARD 2017-18

METRIC	2013-14	2014-15	2015-16	2016-17	2017-18
RESEARCH INCOME					
Research income (£ million) ¹	351	436	351	361	364
Commercial research income (£ million) ²	46.0	55.7	53.6	61.1	61.4
INVENTIVE OUTPUT					
Inventions disclosed ³	323	296	310	332	376
Patent applications filed ⁴	57	66	73	68	77
Patents issued	98	47	59	49	47
Active inventions in portfolio ⁵	977	1007	1021	1009	1026
Patent portfolio ⁶	373	394	404	405	435
LICENSING PERFORMANCE					
New licences signed ⁷	27	39	39	46	43
Invention disclosures licensed	34	60	48	86	63
Active licences held ⁸	175	193	202	205	198
Licences generating income in the period ⁹	71	74	70	64	71
Royalties and fees income generated in the period (£ million)	1.6	2.8	2.1	3.0	1.9
STARTUP FORMATION					
IP startups formed	7	8	6	9	10
Student-based startups formed	8	18	16	23	41
INCUBATION PERFORMANCE					
Startups housed by university incubators	16	18	13	9	19
Startups graduated from an incubator	2	2	4	10	1
Active incubator graduate companies	15	17	21	31	29
STARTUP INVESTMENT					
Venture capital acquired by IP startups (£ million)	254	363	114	123	88
Capital acquired by student-based startups (£ million)	0.8	5.0	9.7	5.1	17.6
STARTUP PERFORMANCE					
IP startups still active	73	74	70	76	79
Income from sale of shares in IP startups (£ million)	–	1.9	1.6	6.6	1.6
Current turnover of all active IP startups (£ million)	45.3	33.6	48.2	80.2	147.3
Jobs supported directly by IP startups	645	814	1,002	974	1273
Student startups still active ¹⁰	14	29	44	66	122
Current turnover of student startups (£ million)	0.9	1.4	2.8	1.2	2.1
New full-time jobs created by student startups ¹⁰	65	89	51	40	64
CONSULTANCY AND TECHNICAL SERVICES¹¹					
Number of projects	559	549	522	543	550
Consultancy income (£ million)	10.8	9.7	9.3	8.5	9.0
Number of companies supported	419	408	414	412	405
Number of lead consultants	297	287	289	284	287
RATIOS					
Invention disclosures per £100 million of research income	92	68	88	92	103
Patents filed per £100 million research income	16	15	21	19	22
Patents issued per £100 million research income	28	11	17	14	13
Licensing and realisation income : research income	0.4%	1.1%	1.1%	2.7%	1.0%
IP startups per £100 million research income	2.0	1.8	1.7	2.5	2.7
Student startups / student population (full-time and part-time)	0.05%	0.11%	0.09%	0.18%	0.22%

¹Total income from research grants and contracts. Years 2015–2017 have been presented under FRS102. All prior years are reported under UK GAAP.

Source: College Annual Report 2016–17. Preliminary figure given for 2017–18.

²Figure shown for 2017–18 is preliminary.

³Staff inventions.

⁴Priority patent applications (does not include any PCT filings).

⁵Invention disclosure portfolio (not patent portfolio).

⁶Count of invention disclosures with patents. 2016–17 figure corrected from 429 stated in 2016–17 Scorecard.

⁷The numbers represent the overall College-related IP commercial agreements as formally reported by Imperial Innovations (which includes options, revenue shares, IP assignments and licences).

⁸Absolute active licences only.

⁹2016–17 figure is corrected from 91 stated in the 2016–17 scorecard.

¹⁰Information is gathered from: Companies House, Crunchbase, Pitchbook, previous startup surveys, Google searches and the Enterprise Lab's data set.

¹¹Delivered through wholly-owned subsidiary Imperial Consultants.

TABLE OF DISRUPTIVE TECHNOLOGIES

A dashboard of 100 wonderful, weird (and possibly worrying) ways the world might change in the foreseeable future

POTENTIAL FOR SOCIO-ECONOMIC DISRUPTION ↑ HIGH ↓ LOW	De Digital footprint eraser 91 DE	Ps Personal digital shields 92 DE	Ht Human head transplants 93 HA	Hc Human cloning & de-extinction 94 HA	Da Distributed autonomous corporations 95 DE	Sp Space solar power 96 SP	El Space elevators 97 SP	Vr Fully immersive virtual reality (VR) 98 DE	Co Artificial consciousness 99 EA	Qt We can't talk about this one 100	
	Ci Conversational machine interfaces 81 MI	Le Life-expectancy algorithms 82 DE	Sa Stratospheric aerosols 83 SP	Br Battlefield robots 84 EA	Ad AI advisors & decision-making machines 85 DE	Ab AI board members & politicians 86 EA	Is Invisibility shields 87 SP	Ph Factory photosynthesis 88 SP	Th Transhuman technologies 89 HA	Te Telepathy 90 HA	
	Ss Planetary-scale spectroscopy 71 SP	Ip Implantable phones 72 MI	He e-tagging of humans 73 DE	Mp Male pregnancy & artificial wombs 74 HA	Dn DNA data storage 75 DE	Gv Genomic vaccines 76 SP	Qs Quantum safe cryptography 77 DE	Cp Cognitive prosthetics 78 HA	Ud Data uploading to the brain 79 HA	Rd Reactionless drive 80 SP	
	Gh Predictive gene-based healthcare 61 DE	Ak Automated knowledge discovery 62 EA	Rs Autonomous robotic surgery 63 EA	Em Emotionally aware machines 64 MI	Xx Humanoid sex robots 65 MI	Bh Human bio-hacking 66 HA	Me Internet of DNA 67 DE	Tc Thought control - machine interfaces 68 MI	Dr Dream reading & recording 69 HA	Wh Whole Earth virtualisation 70 DE	
	Md Mega-scale desalination 51 SP	Sw Self-writing software 52 EA	Mm Public mood monitoring 53 DE	Pb Programmable bacteria 54 SP	Et Peer-to-peer energy trading & transmission 55 DE	La Lifelong personal avatar assistants 56 MI	Sd Smart dust 57 DE	Lc Low-cost space travel 58 HA	Pc Planet colonization 59 HA	Sh Shape-shifting matter 60 SP	
	Mc Medical tricorders 41 DE	Sf Smart flooring & carpets 42 DE	Dt Diagnostic toilets 43 DE	Se Smart energy grids 44 SP	Bf Algal bio-fuels 45 SP	Op Human-organ printing 46 SP	Bs Artificial human blood substitute 47 SP	Nm New materials 48 SP	Fu Fusion power 49 SP	Mr Self-reconfiguring modular robots 50 SP	
	Dl Distributed ledgers 31 DE	Pa Precision agriculture 32 SP	Av Autonomous vehicles 33 EA	Id Intention decoding algorithms 34 MI	Df Drone freight delivery 35 EA	Ap Autonomous passenger aircraft 36 EA	Fp 3D-printing of food & pharmaceuticals 37 SP	Sr Swarm robotics 38 EA	Fd 4-dimensional materials 39 SP	Ze Zero-point energy 40 SP	
	Rc Robotic care companions 21 MI	Sc Smart controls and appliances 22 DE	Cm Cultured meat 23 SP	Ro Delivery robots & passenger drones 24 EA	As Autonomous ships & submarines 25 EA	Rg Resource gamification 26 SP	Wa Water harvesting from air 27 SP	Eb Broadcasting of electricity 28 SP	Bp Bio-plastics 29 SP	Be Beam-powered propulsion 30 SP	
	Cr Cryptocurrencies 11 DE	So Concentrated solar power 12 SP	Pp Predictive policing 13 DE	Eh Micro-scale ambient energy harvesting 14 SP	Wt Airborne wind turbines 15 SP	Ac Avatar companions 16 MI	Mh Metallic hydrogen energy storage 17 SP	Sg Smart glasses & contact lenses 18 HA	Pe Pollution eating buildings 19 SP	Ff Force fields 20 SP	
	Sn Smart nappies 1 DE	Dw Deep ocean wind farms 2 SP	Va Vertical agriculture 3 SP	We Wireless energy transfer 4 SP	Bi Balloon-powered internet 5 SP	Px Powered exoskeletons 6 HA	Cc Computerized shoes & clothing 7 DE	Vt Vacuum-tube transport 8 SP	Sj Scram jets 9 SP	Am Asteroid mining 10 SP	
SOONER ←	TIME*										→ LATER

Example of organisations active in each area

- Monit (South Korea), Abena Nova (Denmark), Siempre Secos (Spain)
- Statoil (Norway), Siemens (Germany), Voltum (US), UMaine (US)
- Green Skies Vertical Farms (US), Aero Farms (US), Neo Farms (Germany), Urban Crop Solutions (Belgium)
- WiTricity (US), Powermat (Israel), Apple/Power By Proxi (US), Qualcomm (US), Mojo Mobility (US), Mopar (US), Fulton Innovation (US)
- Google/Alphabet (US)
- ReWalk (US), Rex Bionics (US), SuitX/US Bionics (US), Ekso Bionics (US), Lockheed Martin (US)
- Google/Alphabet (US), Samsung (Korea), Hexoskin (Canada) Owllet (US), Komodo Tech (Canada), Shiftwear (US), Lechal (India), OM Signal (Canada)
- The Boring Company/Elon Musk (US), China Aerospace Science and Industry Corporation (China)
- Reaction Engines (UK), NASA (US), Boeing (US), Lockheed Martin (US), Airbus (France)
- Deep Space Industries (US), Planetary Resources (US), Made in Space (US)
- Bitcoin (Japan), Ripple (US), Litecoin (US)
- Solarreserve (US), Abengoa (Spain), North China Power Engineering (China), Shanghai Electric (China), Zhejiang Supcon Solar (China), NWEPI (China)
- PredPol (US), ECM Universe (US)
- Pavegen (UK), ECEEN (China)
- Google/Alphabet (US), Joby Energy (US), Altaeros (US), Kitegen (Italy), Enerkite (Germany)
- Pullstring (US), Amazon (US), Alphabet/Google (US), Nintendo (Japan), Invisible Girlfriend/Boyfriend (US)
- NASA (US)
- Alphabet/Verily (US), Amazon (US), Vuzix (US), Eversight (Israel)
- Elegant Embellishments (Germany), iNova (Spain), Studio Roosegaarde (Netherlands), Prosolve 370e (Germany)
- Dstl (UK), Boeing (US)
- Softbank (Japan), AIST (Japan), Blue Frog Robotics (France), Care-o-bot (Germany), Riken/Sumitomo Riko (Japan), Mayfield Robotics (US)
- Amazon (US), Google/Alphabet (US), Philips (Netherlands), Samsung (South Korea), Dyson (UK), Miele (Germany), iRobot (US)
- Impossible Foods (US), Memphis Meats (US), Super Meat (Israel), Finless Foods (US), New Harvest (US)
- Wing/Alphabet (US), Starship Technologies (UK), Volocopter (Germany), eHang (China), Piaggio (Italy)
- Leidos (US), Boeing (US), Rolls Royce (UK)
- Joulebug (US), Waterpebble (UK)
- Permalution (US), Sun to Water (US)
- Powercast (US)
- NatureWorks (US), Gruppo MAIP (Italy), Genomatica (US), Green Dot Bioplastics (US)
- NASA (US)
- Everledger (UK), Stampery (Spain), Brickblock (Germany), Slock.it (Germany)
- Blue River Technology (US), Hortau (Canada)
- Google/Waymo (US), Voyage (US), Nvidia Automotive (US), most major auto-makers
- Amazon (US), Google/Alphabet (US), Philips (Netherlands), Samsung (South Korea), Dyson (UK), Miele (Germany), iRobot (US)
- Google/Alphabet (US), Amazon (US), Flirtey (US)
- Airbus (France), Boeing (US)
- FabCafe (Japan), NASA (US)
- SRI International (US)
- Stratasys (US), Autodesk (US)
- NASA (US)
- Basil Leaf Technologies (US), Dynamical Biomarkers Group (US/Taiwan), Scanadu (US)
- Starwood Hotels (US), MariCare (Finland), Scanalytics (US), Futureshape (Germany)
- Flowsky (Japan), Scanadu (US)
- Tesla (US), ABB (Switzerland), Siemens (Germany), IBM (US), Itron (US)
- Synthetic Genomics/ExonMobil (US), Global Algae Innovations (US), Algenol (US)
- Organovo (US), Envision TEC (Germany), RegenHU (Switzerland), Cellink (Sweden), Seraph Robotics (US)
- HbO2 Therapeutics (South Africa), Biospace (US)
- For example Vantablack by Surrey NanoSystems (UK)
- ITER (EU/France), Tokamak Energy (UK), Alphabet/Google/Tri Alpha Energy (US), General Fusion (Canada), Helion Energy (US), Lockheed Martin (US)
- Festo (Germany)
- Israel Desalination Enterprises Technologies (Israel), Acciona (Spain), Fluence Corporation (US)
- Microsoft (US), Google/Alphabet (US), Open AI (US)
- Open Utility/Escent (UK/Netherlands), Knowelsys (China)
- Gingko Bioworks (US), US Naval Research Laboratory (US), US Army Research Lab (US), Darpa (US)
- Open Utility (UK/Netherlands), Power Ledger (Australia), LO3 energy (US), Energy Web Foundation (Switzerland)
- Konami Corp (Japan), Mitsuku (UK)
- MOOG (US), Darpa (US)
- Space X/Elon Musk (US), Blue Origin (US), Virgin Galactic (UK), Rocket Lab (US), Axiom Space (US), SpaceX (Israel), Firefly Aerospace (US)
- Space X (US), UAE Mars Mission (UAE), NASA (US)
- Intel (US)
- Kite Pharma/Gilead Sciences (US), 23andMe (US), Phenogen Sciences (US), Regeneron (US), Veritas Genetics (US)
- IBM (US)
- Intuitive Surgical (US), Verb Surgical/Alphabet/Johnson & Johnson (US), Da Vinci Surgery (US)
- IBM (US), Toyota (Japan), Mimosys (Japan), Persado (US), Joy AI (US)
- Everledger (UK), Stampery (Spain), Brickblock (Germany), Slock.it (Germany)
- Realbotix (US), True Companion (US)
- BioTeq (UK), Grindhouse Wetwear (US), Dangerous Things (US), see also The Eyeborg Project and the Cyborg Foundation
- Alphabet/Google Genomics (US), Amazon (US), Illumina (US), Oxford Nanopore Technologies/Metrichor (UK)
- CTRL-Labs (US), Emotiv (US), Neuralink (US), maybe Facebook (US)
- No example found
- Improbable (UK)
- European Organization for Astronomical Research in the Southern Hemisphere (European consortium of 16 countries)
- No example found
- Epicenter (Sweden) and Three Square Market 32M (US) are close
- No example found
- Twist Bioscience (US)
- Vaccinogen (US), EpiVax (US), IBM (US), Juno Therapeutics (US)
- Alphabet/Google (US), KETS (UK), IDQ (Switzerland), Isara (Canada)
- Darpa (US)
- Kernel (US), Neuralink/Elon Musk (US), 2045 Initiative (Russia), Darpa (US), General Electric/Braingate (US), possibly Facebook (US)
- NASA (US), Cannae (US)
- Apple (US), Amazon (US), Alphabet/Google (US), Microsoft (US)
- No example found
- CIA (US)
- Lockheed Martin (US), QinetiQ (UK), Boston Dynamics/Softbank (US/Japan)
- Woebot (US), Pefin (US), LV (UK)
- Deep Knowledge Ventures (Hong Kong), Tieto (Finland)
- BAE Systems (UK), Toyota (Japan), NB. Big difference between optical camouflage and bending light to make things disappear
- Breakthrough Energy (US), RIPE (US), Joint Centre for Artificial Photosynthesis (US)
- SENS Research Foundation (US), Methuselah Foundation/Peter Thiel (US)
- Facebook (US), Neuralink/Elon Musk (US)
- Suicide Machine (Netherlands), Just Delete Me (US)
- No example found
- Turin Advanced Neuromodulation Group (Italy)
- Sooam (South Korea), Revive and Restore (US)
- No example found
- Rebeam (US), Solaren Corp (US)
- Thoth Technology (Canada)
- Improbable (UK), HelloVR (US), Magic Leap (US), Microsoft (US). See also Mind Maze (US), Facebook (US) and possibly Apple (US)
- Possibly Alphabet/Google (US)
- As it says, we can't say

* Time is defined as ubiquity or mainstream use not invention

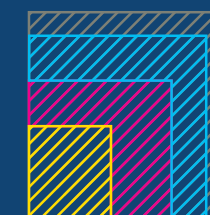
STIMULATING DEBATE

Published by Imperial Tech Foresight in January 2018, the Table of Disruptive Technologies helps prepare for the future by presenting a mixture of prediction and provocation. It was described by the *Financial Times* as 'brave' and the *Business Insider* warned it might 'blow your mind'.

Imperial Tech Foresight is the College's dedicated foresight practice, creating space for business leaders to immerse themselves at the fringes of disruption, and explore breakthrough technology and research through visionary academic perspectives.

Examples are purely illustrative and do not constitute any form of recommendation, validation or investment advice. The Table was conceived and created by Richard Watson, Dr Anna Cupani and the Imperial Tech Foresight team. www.imperialtechforesight.com

Legend



Ghost Technologies: Fringe science & technology. Defined as highly improbable, but not actually impossible. Worth watching.

Horizon 3: Distant future 20 years + (Explore).

Horizon 2: Near future 10-20 years hence (Experiment).

Horizon 1: Happening now (Execute).

How to read entries

Sn — Abbreviation of technology

Smart nappies — Description of technology

1 DE — Theme (See next right)

Examples (See right hand panel)

Themes

Each of the 100 technologies has been subjectively categorised according to five broad themes, which are:

- DE** Data Ecosystems
- SP** Smart Planet
- EA** Extreme Automation
- HA** Human Augmentation
- MI** Human-Machine Interactions

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

The work represented in this report covers 1 August 2017-31 July 2018. It 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 and its parent companies Touchstone Innovations and IP Group. 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.

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