Imperial College London

REVIEW OF ENTERPRISING ACTIVITY

2016-17

INTRODUCTION

PROFESSOR JAMES STIRLING

PROVOST, IMPERIAL COLLEGE LONDON

It gives me great pleasure to introduce Imperial's first *Review of Enterprising Activity*, which comes at a time of exciting new opportunity for staff and student enterprise at the College.

Imperial has a deserved reputation for education, research and translation of discoveries into benefits for society. Its support for enterprise pervades all three sectors.

Universities are increasingly being charged to become more innovative, dynamic and connected. This review celebrates Imperial's significant response to this challenge: a unique innovation and enterprise ecosystem, and a world-leading community of staff and students who act boldly and courageously to identify and pursue new opportunities.

The following pages highlight our approach to establishing and managing collaborations with leading companies to the benefit of all parties. They describe the support the College provides to its innovative staff, and they celebrate the entrepreneurial education we provide our students.

I am particularly pleased to introduce you to two new facilities in which the College has invested (page 8) and which launched during the reporting year of this review (August 2016 – July 2017): the Enterprise Lab – our new dedicated space for student entrepreneurs on our South Kensington Campus, and the White City Incubator – Imperial's hub for early-stage companies in need of capital-intensive laboratory state-of-the-art facilities.

I am delighted to see all this activity compiled into a public report for the first time, and I hope that you enjoy reading it.

Cover picture: The cover photo shows equipment for generating tuneable infrared light. It is used by researchers from Imperial's Institute of Chemical Biology in research collaborations with AstraZeneca and Syngenta to improve the design of drugs and herbicides, respectively.

FOREWORD

DR SIMON HEPWORTH

DIRECTOR, ENTERPRISE, IMPERIAL COLLEGE LONDON

Technology transfer and knowledge exchange represent a significant investment for Imperial.

They underpin the College's long-term interests in attracting and developing the best staff and student talent, collaborating with industry in meaningful ways, and generating impact from its work for the benefit of society at large. Impact occurs in many ways. Here, we particularly focus on collaborations with pioneering corporate partners, and the creation of vibrant startup companies.

This review sets out some of the ways we work to transform research findings into new or improved products and services. It also describes how we seek to create an environment that encourages innovative thinking and maximises the exchange of ideas. Building a vibrant group of corporate partners, startup companies and investors and integrating them into the Imperial community are essential parts of this work.

I am delighted that the scale of Imperial's research collaborations with industry has increased during this reporting period. Growth has been not only in terms of financial value, but also in geographic reach and sectoral diversity (page 17). We are grateful to all our partners for your support.

On the entrepreneurship side, more startups have been formed than ever before, based on the intellectual property (IP) of College and the ideas of students (page 6). As a vibrant entrepreneurial environment becomes an increasingly strong competitive driver for attracting staff and students, so we continue to strengthen our support and service provision for startups.

Looking ahead, we are already working on three new activities that will feature in our report next year:

- In August 2017 we launched Founders Choice®, based on a policy change enabling academics to secure up to 95% equity of a startup company based on their research. This is the first such model in a UK university and we look forward to tracking uptake and reviewing progress with our academics.
- In October 2017 we launched the Imperial Venture Mentoring Service to provide Imperial innovators with impartial advice from a pool of highly qualified volunteer top business mentors.
- In January 2018 we started to pilot Techcelerate – our first accelerator programme specifically designed for postdocs to fast-track the commercial development of their ideas and to strengthen their entrepreneurial skills.

We look forward to working with existing and new partners as we seek to build novel research collaborations, expand our IP-based startup activity, and realise more of the exciting co-location possibilities offered by Imperial's evolving White City campus. We hope that this review brings alive some of the benefits of being part of Imperial's ecosystem, and inspires you to get in touch with us.

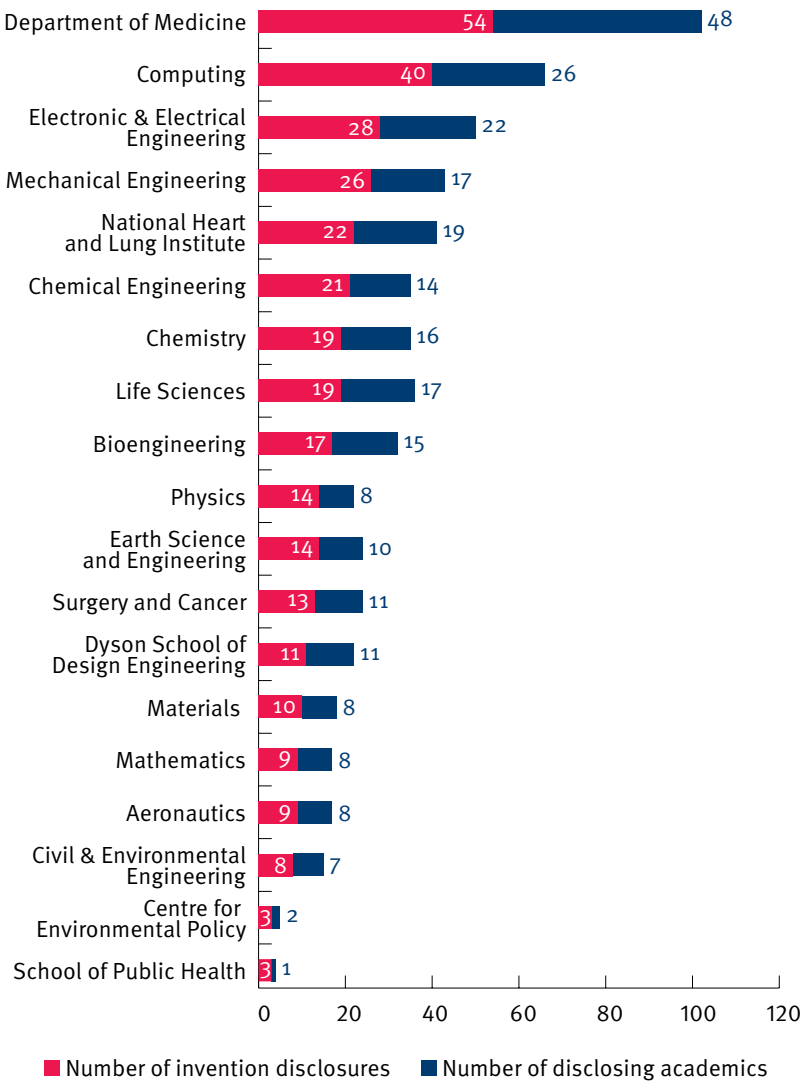
Imperial College London is one of the world's leading universities. The College's 17,000 students and 8,000 staff are expanding the frontiers of knowledge in science, medicine, engineering and business, and translating their discoveries into benefits for our society.
Imperial is the UK's most international university, according to Times Higher Education, with academic ties to more than 150 countries. In May 2017, 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 2016 – 31 July 2017. It was carried out by Imperial's 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 company Touchstone Innovations. The College would also 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.

INVENTIVE OUTPUT

Imperial measures the inventive output of its academic community in two ways: invention disclosures and patents. Academics are encouraged to register discoveries and new ideas as invention disclosures, as and when they occur during their research activities. Disclosures can include breakthroughs such as new types of device to assist a surgeon, a new use of a molecule with a particular influence in the human body, a new type of solar cell, or a new measurement technique. The invention disclosure forms the basis of the documentation used to determine whether patent protection should subsequently be sought.

FIGURE 1: Distribution of invention disclosures by academic department at Imperial



Invention disclosures

In 2016-17 Imperial's academic community generated 332 invention disclosures, reflecting slight growth over previous years. With a total research volume of £361m, the productivity of invention was 92 disclosures per £100m of research. A total of 268 academics from a population of 1,243 disclosed inventions (over 21%). Benchmarking suggests this is highly competitive compared with peer universities in the UK and USA.

The distribution of invention disclosures by academic department (Figure 1) shows widespread inventive output, with 12 out of 22 academic departments having 10 or more active academic inventors.

Patents

All invention disclosures are assessed by Imperial Innovations, the College's technology transfer office, to determine which ideas and discoveries have potential for commercial use. Where staff at Imperial Innovations see such potential, they will seek to protect the IP in the invention disclosures, most commonly through the patenting process. Protection is essential to future commercialisation, enabling inventors to assert ownership over discoveries and prevent others from using them without permission.

In 2016-17 Imperial Innovations filed 68 new patent applications, feeding into the patent application pipeline, which can take one to three years to complete. During the same period, 40 patents were granted, taking the College's total patent base held by Imperial Innovations to 1,009. The application pipeline contained 419 prospective patents at year end. The scale of patenting activity in 2016-17 is consistent with previous years, reflecting a steady effort to protect Imperial discoveries. Approximately one in five invention disclosures are taken forward to patent application.

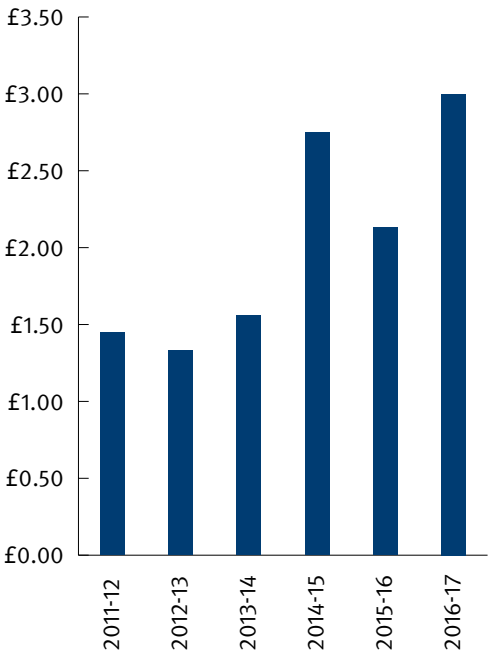
TECHNOLOGY LICENSING PERFORMANCE

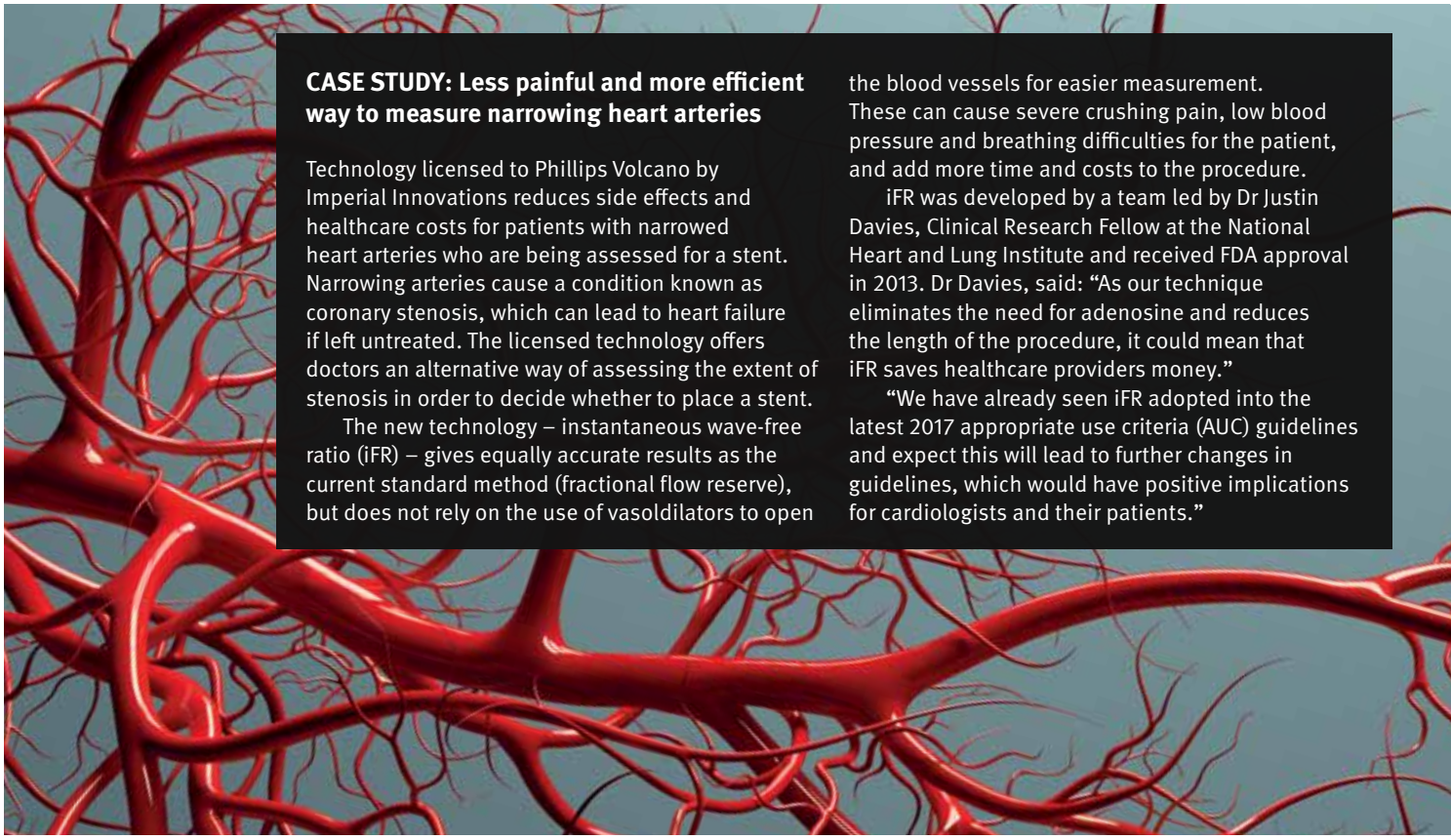
Once IP is protected through patenting or other forms, Imperial Innovations seeks to secure interest from external partners in commercialising the IP. This is typically achieved through licensing to existing corporate partners, or if the IP is too early for market adoption, through licensing to startup companies. Measures of success in commercialisation are therefore the scale and diversity of the licensing activity, and the number and health of the startup companies formed.

With regard to licensing activity, Imperial Innovations completed 46 IP-related transactions during the year – an 18% increase on the previous year (39). IP transactions signed include six in Pharma and Biotech, three in Medical Devices, five in Industrials and one in the Healthcare Provider sector.

Imperial Innovations has a portfolio of licences from several years of activity: 91 of these generated fee and/or royalty income in the period, collectively generating £3m in revenue – the strongest performance in the last six years (Figure 2). In accordance with the College's policies, some of this income is shared with academic departments and individual inventors. The remainder is used by Imperial Innovations to offset the costs of running the technology transfer activity, which includes the patent budget.

FIGURE 2: Licensing revenue (£m) at Imperial College London 2011 – 2017





CASE STUDY: Less painful and more efficient way to measure narrowing heart arteries

Technology licensed to Phillips Volcano by Imperial Innovations reduces side effects and healthcare costs for patients with narrowed heart arteries who are being assessed for a stent. Narrowing arteries cause a condition known as coronary stenosis, which can lead to heart failure if left untreated. The licensed technology offers doctors an alternative way of assessing the extent of stenosis in order to decide whether to place a stent.

The new technology – instantaneous wave-free ratio (iFR) – gives equally accurate results as the current standard method (fractional flow reserve), but does not rely on the use of vasoldilators to open the blood vessels for easier measurement. These can cause severe crushing pain, low blood pressure and breathing difficulties for the patient, and add more time and costs to the procedure.

iFR was developed by a team led by Dr Justin Davies, Clinical Research Fellow at the National Heart and Lung Institute and received FDA approval in 2013. Dr Davies, said: "As our technique eliminates the need for adenosine and reduces the length of the procedure, it could mean that iFR saves healthcare providers money."

"We have already seen iFR adopted into the latest 2017 appropriate use criteria (AUC) guidelines and expect this will lead to further changes in guidelines, which would have positive implications for cardiologists and their patients."

STARTUP PERFORMANCE

Startup companies provide a useful metric of inventiveness and entrepreneurial intent. They are based on the IP of the College and the ideas of students.

Startups at Imperial are categorised in three ways:

- **IP startups:** companies founded to exploit IP owned by Imperial. These are typically led by the academic staff who made the initial discovery, and are often referred to as staff-based startups. Such companies can also be led by postdocs or students.
- **Student startups:** companies founded by Imperial students during their degree courses, from their own ideas or discoveries. Whilst IP generated by College staff is owned by the College, students can file their own patents on discoveries that they make. Accordingly students are free to pursue startup companies to progress their own ideas, and are encouraged to do so as part of their student experience at Imperial.
- **Alumni startups:** companies founded by Imperial students after they graduate.

Formations

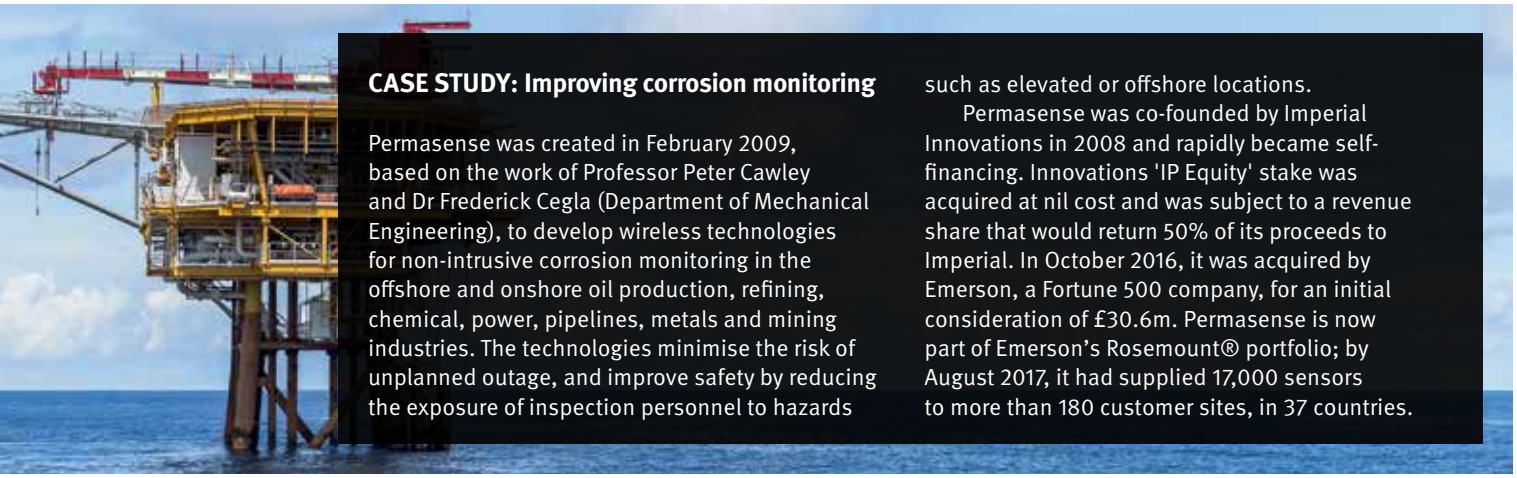
A key measure of success is the number of startups formed in the year. 2016-17 was a record year with the formation of 9 IP startups and 16 student startups. Figure 3 (page 9) shows a notable growth in student startups over the last five years, reflecting a combination of increased appetite and improved resources and support. Entrepreneurship is popular within the student base, with startups now being a potential career choice for some, although multinationals and government still remain more popular.

Whilst student startups might be expected to be lighter in nature than IP startups, encouragingly, student companies tend to take a bold and deep approach, tackling grand societal challenges or progressing technologies arising from serious scientific research. The distribution of student startups by sector shows strong representation in the Technology and Medical Devices sectors – a far cry from 'new ways to deliver pizza'. This sector focus is mirrored by the IP startups, where the strong representation in Technology and Medical Devices is augmented by activity in Basic Materials and Energy. (Figure 4, page 9).

Startup growth, survival and acquisitions

Of equal importance to startup formation is the progress made by existing startup companies from Imperial (Table 2, page 11), which can be measured through a wide range of metrics including investment secured and number of employees. A total of 136 startups remain active, six of which are listed on stock exchanges. Collectively they support 1,316 jobs. In 2016-17 the startups secured £125m in new investment. The vast majority of this was achieved by the IP startups, which typically require significant technology development before they reach the point of achieving sales revenues.

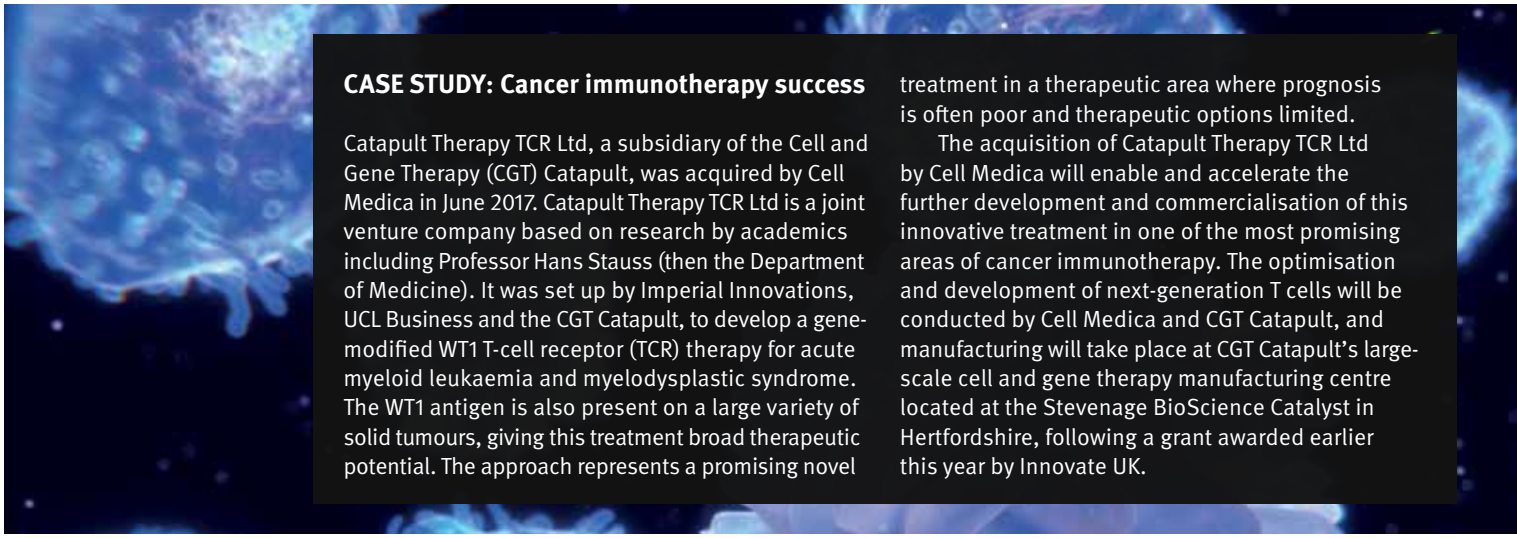
Table 2 provides a snapshot of startup performance in year (see scorecard data for the full picture on inside back cover). Notable investment rounds are listed in Table 3 (page 12). For the student startups, early signs of growth can be measured through prizes won and programme admissions secured (Table 4, page 12). The number of notable client contracts secured by a startup also gives an indication of future sales potential (Table 5, page 13). A final measure of startup company success is attractiveness for acquisition by larger corporate partners. In 2016-17 there were four notable 'exits' by acquisition by third parties (see case studies below), taking the total number of acquisitions since 2000 to 30 companies.



CASE STUDY: Improving corrosion monitoring

Permasense was created in February 2009, based on the work of Professor Peter Cawley and Dr Frederick Cegla (Department of Mechanical Engineering), to develop wireless technologies for non-intrusive corrosion monitoring in the offshore and onshore oil production, refining, chemical, power, pipelines, metals and mining industries. The technologies minimise the risk of unplanned outage, and improve safety by reducing the exposure of inspection personnel to hazards such as elevated or offshore locations.

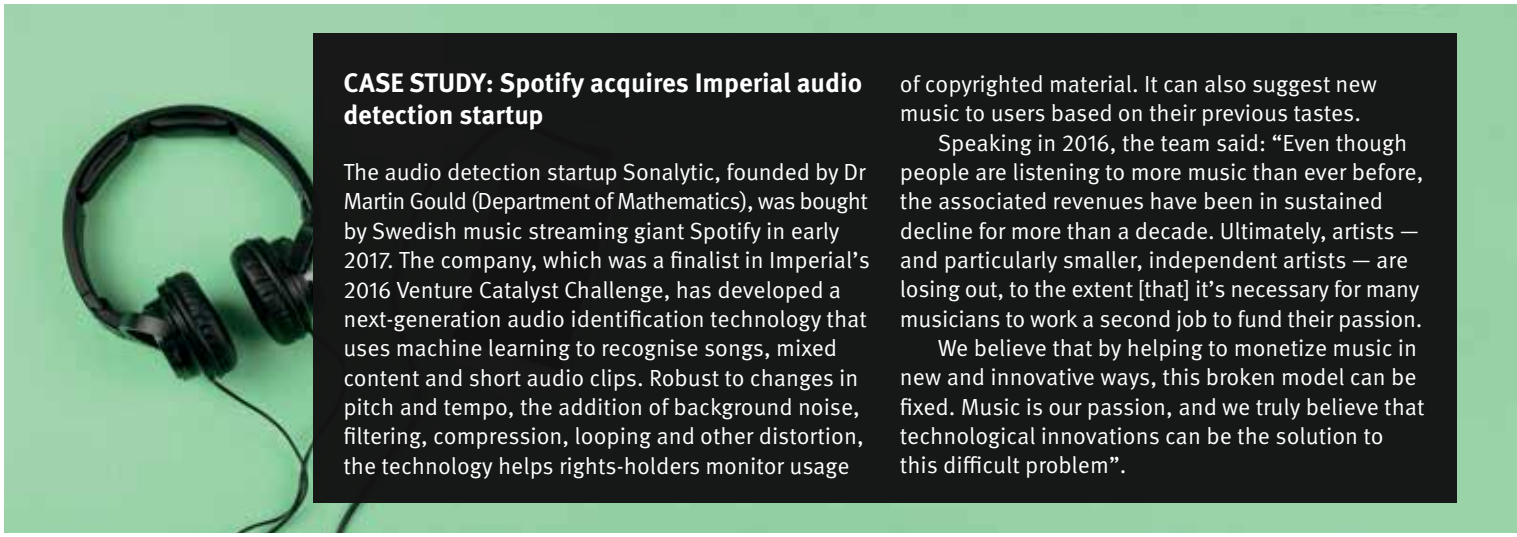
Permasense was co-founded by Imperial Innovations in 2008 and rapidly became self-financing. Innovations 'IP Equity' stake was acquired at nil cost and was subject to a revenue share that would return 50% of its proceeds to Imperial. In October 2016, it was acquired by Emerson, a Fortune 500 company, for an initial consideration of £30.6m. Permasense is now part of Emerson's Rosemount® portfolio; by August 2017, it had supplied 17,000 sensors to more than 180 customer sites, in 37 countries.



CASE STUDY: Cancer immunotherapy success

Catapult Therapy TCR Ltd, a subsidiary of the Cell and Gene Therapy (CGT) Catapult, was acquired by Cell Medica in June 2017. Catapult Therapy TCR Ltd is a joint venture company based on research by academics including Professor Hans Stauss (then the Department of Medicine). It was set up by Imperial Innovations, UCL Business and the CGT Catapult, to develop a gene-modified WT1 T-cell receptor (TCR) therapy for acute myeloid leukaemia and myelodysplastic syndrome. The WT1 antigen is also present on a large variety of solid tumours, giving this treatment broad therapeutic potential. The approach represents a promising novel treatment in a therapeutic area where prognosis is often poor and therapeutic options limited.

The acquisition of Catapult Therapy TCR Ltd by Cell Medica will enable and accelerate the further development and commercialisation of this innovative treatment in one of the most promising areas of cancer immunotherapy. The optimisation and development of next-generation T cells will be conducted by Cell Medica and CGT Catapult, and manufacturing will take place at CGT Catapult's large-scale cell and gene therapy manufacturing centre located at the Stevenage BioScience Catalyst in Hertfordshire, following a grant awarded earlier this year by Innovate UK.

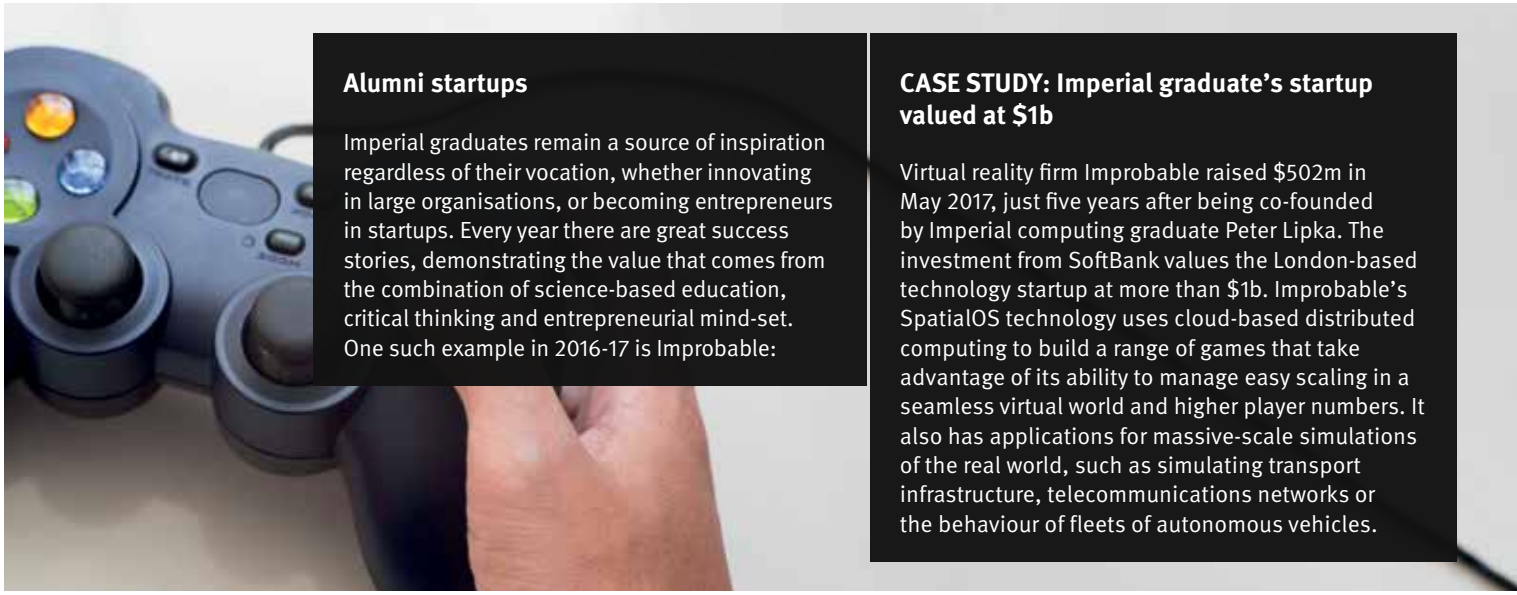


CASE STUDY: Spotify acquires Imperial audio detection startup

The audio detection startup Sonalytic, founded by Dr Martin Gould (Department of Mathematics), was bought by Swedish music streaming giant Spotify in early 2017. The company, which was a finalist in Imperial's 2016 Venture Catalyst Challenge, has developed a next-generation audio identification technology that uses machine learning to recognise songs, mixed content and short audio clips. Robust to changes in pitch and tempo, the addition of background noise, filtering, compression, looping and other distortion, the technology helps rights-holders monitor usage of copyrighted material. It can also suggest new music to users based on their previous tastes.

Speaking in 2016, the team said: "Even though people are listening to more music than ever before, the associated revenues have been in sustained decline for more than a decade. Ultimately, artists — and particularly smaller, independent artists — are losing out, to the extent [that] it's necessary for many musicians to work a second job to fund their passion.

We believe that by helping to monetize music in new and innovative ways, this broken model can be fixed. Music is our passion, and we truly believe that technological innovations can be the solution to this difficult problem".



Alumni startups

Imperial graduates remain a source of inspiration regardless of their vocation, whether innovating in large organisations, or becoming entrepreneurs in startups. Every year there are great success stories, demonstrating the value that comes from the combination of science-based education, critical thinking and entrepreneurial mind-set. One such example in 2016-17 is Improbable:

CASE STUDY: Imperial graduate's startup valued at $1b

Virtual reality firm Improbable raised $502m in May 2017, just five years after being co-founded by Imperial computing graduate Peter Lipka. The investment from SoftBank values the London-based technology startup at more than $1b. Improbable's SpatialOS technology uses cloud-based distributed computing to build a range of games that take advantage of its ability to manage easy scaling in a seamless virtual world and higher player numbers. It also has applications for massive-scale simulations of the real world, such as simulating transport infrastructure, telecommunications networks or the behaviour of fleets of autonomous vehicles.

New programme to help academics create research-led businesses

In a first for any UK university, Imperial has launched a programme offering academics a choice between two routes for founding spinout companies. Created by the College with the support of Imperial Innovations, Founders Choice® was developed in response to the evolving entrepreneurial ecosystem at the College to encourage more academics to create real impact through their research-led businesses. It has been launched initially as an 18-month pilot, with roadshows throughout College departments during 2016-17.

The new Founder-driven route recognises the knowledge and expertise in innovation and entrepreneurship that have developed among academics at Imperial by offering them up to 95% of founding equity and more developmental freedom and responsibility. A basic level of support would still be provided by Imperial Innovations, including training, template legal documents and access to professional advisers. Imperial Innovations will also maintain any patents on the founding technology to an agreed level and for a set period.

The existing option for startups at Imperial – the jointly driven route – will continue to offer academics full support from Imperial Innovations, with founding equity split more evenly between the founders and Imperial.

Dr Simon Hepworth, Director of Imperial's Enterprise Division, said: "Founders Choice has been developed in response to requests for increased flexibility from our academic community and government. It has been well-received within our academic community and the College hopes the new approach will encourage even wider engagement and more licensed spinout companies to increase impact of our research by commercialising research results."

Support for enterprising students

In October 2016 Imperial opened a new centre for students wishing to broaden their entrepreneurial skills. In the innovative spirit of repurposing and hacking, the slick and modern Enterprise Lab was built from storage space in the basement of the College Library, creating Imperial's own slice of Silicon Valley in South Kensington.

The Enterprise Lab is home to a 'green room' performance simulator, which forms part of a collaboration with the Royal College of Music, a high-tech boardroom and presentation spaces. It offers state-of-the-art digital tools, techniques and training to help students build better business plans and improve their performance at pitching to potential clients, partners or investors. The space also gives students the knowledge, skills and experience to compete for the best jobs and make a real impact in the companies that hire them.

Since its opening, the Enterprise Lab has held a substantial programme of training, mentoring, speaking events and workshops. Its events during Enterprise Week in March 2017 attracted over 1,100 attendees and generated significant social media activity. This year, more than twice as many participants entered the College's flagship programmes to encourage enterprise activity: WE Innovate (formerly Althea programme) and the Venture Catalyst Challenge.

Enterprise Lab complements the many entrepreneurship programmes run in faculties, departments and research centres. These are equally innovative and buoyant with talent and ideas. They include the Faculty of Natural Sciences Make-a-Difference competition (FONSMAD), the Centres for Doctoral Training's Dragons' Den, and the SynbiCITE Bio-start competition to commercialise the engineering of biology.

Building an entrepreneurial ecosystem at White City

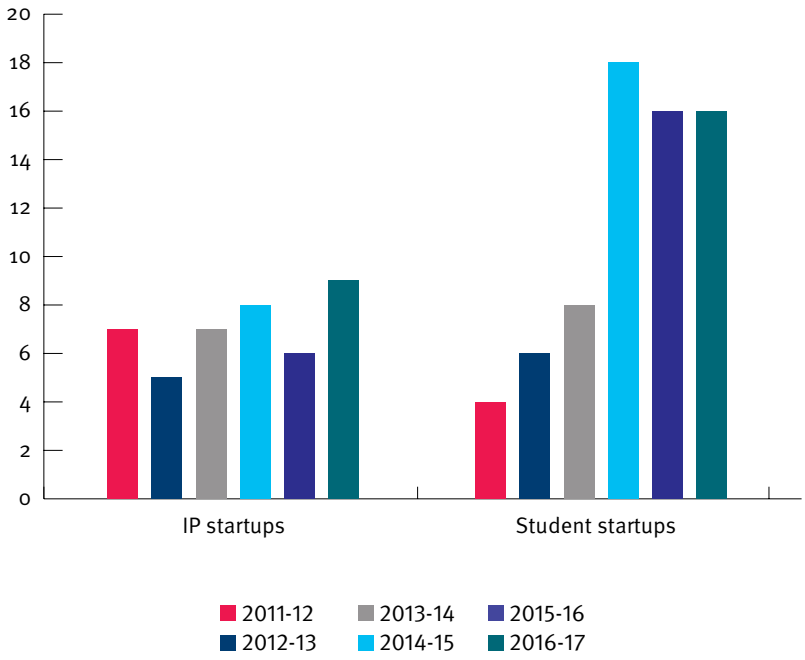
In October 2016 Imperial opened the White City Incubator – a hub for innovation and entrepreneurship with office, laboratory space and support for early-stage companies. The two-storey, 18,000 square foot facility contains 10 laboratories, 12 offices, meeting rooms and break-out areas. It builds on 10 years of experience running the South Kensington Incubator, the space for which was returned to academic use in April 2017.

The White City Incubator is one of only three such facilities in central London that provide wet labs, presenting a major boost to Pharma & Biotech, Medical Devices and Industrials sectors. It lowers the barrier to entry for startups in need of capital-intensive lab environments, which would otherwise need to raise over £1m in capital just to acquire and fit out a lab.

The Incubator operates on a simple occupancy fee model: it does not take any equity from the startups, leaving them free to pursue their own investor strategies. It provides dedicated laboratories for single client occupancy as well as a shared laboratory for deep science startups at the very beginning of their journey, who cannot afford to take on the expense of their own fully equipped laboratory. The shared lab provides basic equipment and consumables to help incredibly innovative companies take the first step on their journey. Guidance is provided to those startups that want it, together with a series of community events, encouraging peer-to-peer communication and learning.

By July 2017 the Incubator reached 75% occupancy with nine startups taking space in the facility (Table 6). Of these, three are directly affiliated with Imperial through IP.

FIGURE 3: Number of IP and student startups formed at Imperial 2011-17



The Incubator therefore provides a convening role beyond Imperial, bringing together deep science startups into an ecosystem at White City, where the cluster effect can increase their chances of success. The Incubator is located within the I-Hub building operated by Imperial College Thinkspace, in which startups, scaleups and corporate partners can take office space ranging from one or two desks in the co-working environment of Central Working, through to complete floors, some of which have infrastructure to support wet labs. During 2016-17 the I-Hub welcomed Mapi, Cybio and the Oil and Gas Climate Initiative as new occupants.

Startups are welcome to stay in the incubator for up to three years, after which they will be asked to make way for new entrants. This timescale is significantly longer than that allowed by many incubators, recognising the longer timescales required to develop technologies in life sciences and physical sciences fields, compared with software applications.

After three years the startups will be assisted in finding facilities in which to scale up their business. Imperial College Thinkspace provides such facilities within the I-Hub, together with other facilities on the White City campus such as Forest House, currently home to Autolus, and Centre House, home to DNA Electronics and Microtest.

FIGURE 4: Imperial IP and student startups by sector

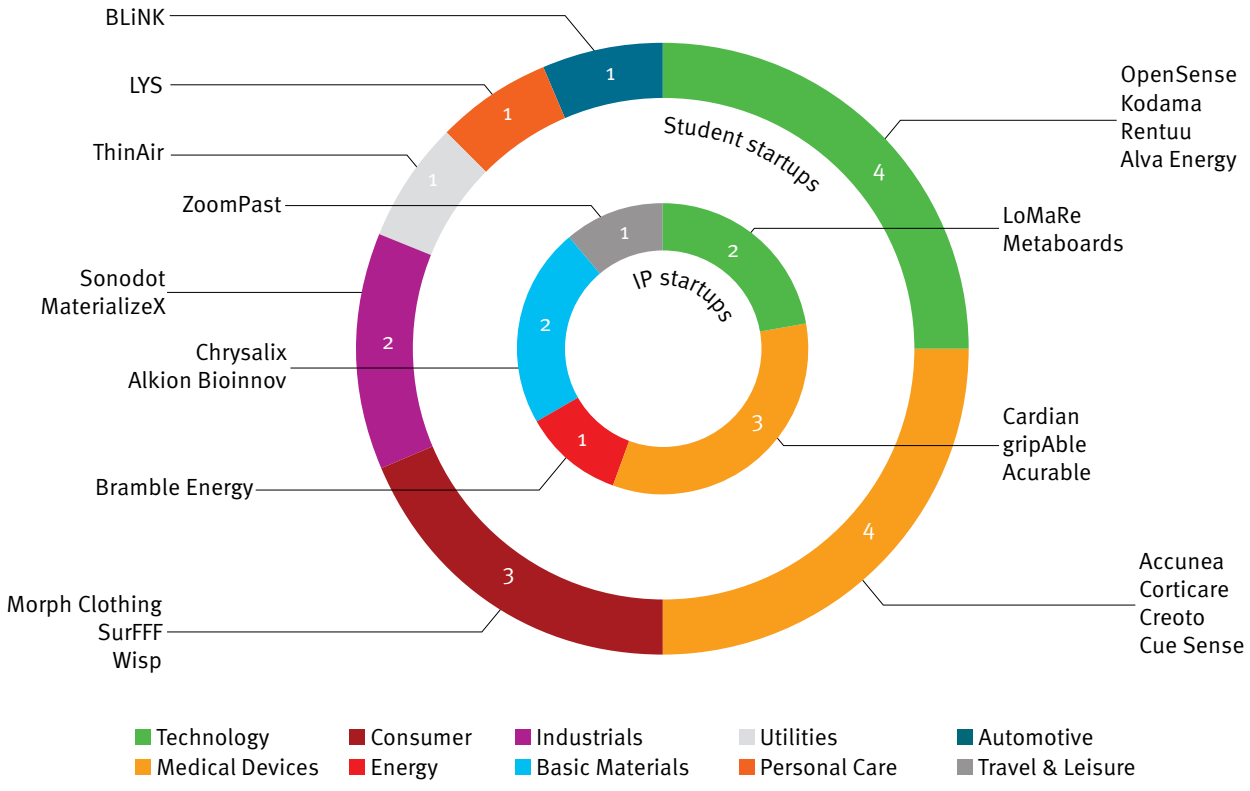


TABLE 1: Imperial startups formed (incorporated) in 2016-17

Sector	Type	Startup	Idea
Technology	IP	LoMaRe	A robust and efficient form of data storage that uses characteristics of new materials.
		Metaboards	A platform for the wireless transmission of power and data between electronic devices, developed jointly with Unversity of Oxford.
	Student	Alva Energy	An innovation that combines clean energy technology applications and blockchain 'mining' to power a computing server using excess energy.
		Kodama	A learn-through-play platform, composed of physical toys and a digital content platform, enabling children to play together.
		OpenSense	Pollution sensors on paper, which stick on the back of smartphones and measure pollution in the air.
		Rentuu	An online renting platform – for the house, rented apartment, or even camping trip.
Medical Devices	IP	Acurable	A low-power sensor to monitor breathing and heart rate during sleep.
		Cardian	A novel, implantable Surface Acoustic Wave device that improves the monitoring and treatment of cardiac failure patients by providing automated, continuous, wireless monitoring of blood pressure in the pulmonary artery.
		gripAble	A lightweight electronic handgrip to detect flicker movements by users with significant grip impairment and channel them into controlling a computer game.
	Student	Accunea	A bedside kidney monitoring device to detect kidney injury earlier than existing technologies.
		Corticare	A portable and smart device that uses novel biomimetic materials for affordable, quick and accurate hormonal testing.
		Creoto Limited	Programmable smart sockets for amputees to use their smart phone to customize their comfort level according to body type and daily activities.
		Cue Sense	A collective of makers, thinkers and doers dedicated to solving real-world problems, such as developing assistive technology for the visually impaired to facilitate social interactions.
Consumer	Student	Morph Clothing	An innovative sizing system that uses data analysis to transform menswear design.
		SurFFF	A novel method of surfboard manufacturing that uses 3D printing to convert ocean, recycled plastic and bio-based waste into compostable, recyclable surfboards.
		Wisp	A collection of accessories to encourage conversations about female sexuality and prioritise women's sexual desire.

Sector	Type	Startup	Idea
Industrials	**Student**	**MaterializeX**	A novel, adhesive and complementary machine learning software platform for adhesive optimisation.
		Sonodot	A high-performance, low-power, user-friendly indoor positioning system for tracking high-value assets or perishable goods.
Basic Materials	**IP**	**Alkion Bioinnovations**	Utilisies IP from Alkion Biopharma to develop products for the Agrichemical sector, including natural food additives, natural flavours, essential oils and biopesticides.
		Chrysalix technologies	An innovative biomass fractionation process using low-cost ionic liquids to recover metals from treated waste wood.
Energy	**IP**	**Bramble Energy**	A new type of fuel cell based on printed circuit boards that are combined into stacks for more energy-intensive applications.
Automotive	**Student**	**BLiNK**	A communications device to help pedestrians communicate with driverless cars.
Personal Care	**Student**	**LYS**	A user-focused, light-measuring wearable device and app to track light intake for a healthy sleep–wake cycle.
Travel & Leisure	**IP**	**ZoomPast**	A data visualisation tool to facilitate the organisation and exploration of relationships between different pieces of information in large data sets for the genealogy market.
Utilities	**Student**	**ThinAir**	An efficient biomembrane to collect water from the air around us, combining principles used in nature with material science to create a surface on which water rapidly condenses.

TABLE 2: Progress of Imperial startups

Criteria	IP Startups	Student Startups	Total
Number of active startups (as at 31 July 2017)	70	60	130
Number of listed startups (as at 31 July 2017)	6	0	6
Number of startups acquired by third parties (since 2000)	24	6	30
Investment funds secured in 2016-17 (£m)	124	1	125
Jobs supported directly	974	342	1,316

TABLE 3: Notable investment rounds for Imperial startups 2016-17

Sector	Startup	Amount raised (£m)	Context
Pharma & Biotech	**Pulmocide**	25	In March 2017, the UK-based drug discovery company Pulmocide Ltd, which develops novel compounds for inhaled delivery to treat respiratory syncytial virus and pulmonary aspergillosis, announced the completion of a $30.4m Series B financing round. The round was led by new investor SR One and included Longwood Fund plus existing investors SV Life Sciences, F-Prime Capital, Johnson & Johnson Innovation – JJDC, Inc. and Touchstone Innovations plc.
	Abzena	25	Abzena (formerly known as PolyTherics) provides proprietary technologies and complementary services for developing and manufacturing biopharmaceutical products. In April 2017, it announced a £25m placing.
Utilities	**Ceres Power**	20	In the past year, Ceres began testing its home power systems in the UK, bolstered by a joint development agreement for a residential power system. It also signed a separate joint development licence agreement to develop and launch a Multi-kW combined heat and power product with a leading global Original Equipment Manufacturer. In September 2016, the company successfully closed a £20m placing.
Medical Devices	**Veryan Medical**	13.5	Veryan is a specialist in vascular disease that has developed and patented BioMimics 3D stent technology. The company secured £13.5m in funding, comprising a funding round with existing investors, including Touchstone Innovations plc, and a €5m loan from the Silicon Valley Bank. The funding will allow the company to continue its progress towards US and Japanese regulatory approval.
Industrials	**Microsaic**	5.4	Microsaic develops and markets next generation mass spectrometry (MS) instruments for analysing gaseous, liquid and solid samples. It has successfully miniaturised MS by integrating key components onto patented chip technologies. The company is repositioning to focus on the pharma and biopharma sectors, successfully raising £5.4m to support these efforts.
	Impression Technologies	3	Impression has developed technology for cost-effective, lightweight production of vehicle structures in the automotive and transport sectors. It opened a new factory in Coventry in October 2016, enabled by a £4m investment round by Touchstone Innovations plc and Mercia Technologies the previous year. In June 2017, Impression closed a £3m series B investment round, with Touchstone committing £1.5m to the round. The funding will enable the company to secure further partnerships and supply relationships.
Technology	**Cortexica**	2	Cortexica provides advanced visual search and image recognition software to global retailers, brands and digital publishers. The company secured a further £2m from Touchstone Innovations plc.
	Slamcore	1	Slamcore is developing a series of Simultaneous Localization and Mapping technologies. In May 2017, the company announced seed funding secured from Amadeus Capital Partners, SPARX Group, and Toyota AI Ventures.
Food & Nutrition	**Skipping Rocks Labs**	0.85	Skipping Rocks Lab's mission is to make packaging waste disappear. Their Ooho! Product is a sustainable packaging alternative to plastic bottles and cups, made from a seaweed extract. Skipping Rocks Labs secured £0.85m on Crowdcube.

TABLE 4: Notable student startup successes in 2016-17

Sector	Startup	Prize / Award value (£k)	Context
Industrials	**Customem**	100 25	Won first prize in Bio-start competition run by SynbiCITE. Won the 2017 Armourers and Brasiers' Company Venture Prize.
	GetTRIK	50	Founder Pae Utoomprurkporn Natwilai won a Women in Innovation Award from Innovate UK.
Food & Nutrition	**Skipping Rocks Lab**	–	Won Wired Retail 2016 startup of the year.
Utilities	**ThinAir**	–	Won Enterprise Nation's 2017 Student Startup of the Year competition, McKinsey Venture Academy and CleanTech Challenge.

TABLE 5: Notable activity with clients 2016-17

Sector	Startup	Context
Pharma & Biotech	**Cell Medica**	Cell Medica develops, manufactures and markets cellular immunotherapy products for treating cancer and infections. The past year saw Cell Medica establish two significant collaborations: the first was with University College London (UCL) to develop T-cell receptor products for treating cancer; the second was an expansion of Cell Medica's partnership with Baylor College of Medicine to develop an off-the-shelf allogeneic cell therapy. Cell Medica also acquired Catapult Therapy TCR, a joint venture formed by Imperial Innovations, UCL Business and The Cell and Gene Therapy Catapult.
	Circassia	This pharmaceutical company's phase 2 house dust mite clinical trial failed due to high placebo effect. The company has now abandoned allergy programmes and is refocussing on speciality pharmaceutical products in the respiratory space. It signed a $230m collaboration with AstraZeneca during the year.
	PsiOxus	PsiOxus Therapeutics is an immuno-oncology company that has developed a patented platform for the systemic delivery of tumour-targeted oncolytic immune therapeutics. The company was founded in 2010 in its present form, having been created by the merger of Imperial spinout Myotec Therapeutics with Oxford spinout Hybrid BioSystems. In late 2016 PsiOxus signed two deals with Bristol-Myers Squibb receiving $60m in upfront payments, with the potential of further payments upwards of $886m in development, regulatory and sales-based milestones, as well as royalties on net sales.
Medical Devices	**DNAe**	DNA Electronics is a pioneer in next-generation sequencing and has developed technology that enables point-of-need rapid DNA analysis. In September 2016 the company was awarded a $51.9m contract by BARDA to support the testing and FDA clearance of DNAe's sequencing platform. Accordingly, a new US facility was opened in February 2017 and the brand for its diagnostic platform, LiDiaTM, announced.
	IXICO	IXICO is a provider of imaging solutions for clinical trials, research studies and diagnostics in the Pharmaceutical and Medical Devices sectors. It has secured several contracts throughout the year, including a US$1.5m contract for services to a Phase IIb clinical trial on the early stages of progressive supranuclear palsy, a US$1.2 million contract with a global pharmaceutical, a major EU public–private consortium focusing on amyloid imaging to prevent Alzheimer's Disease, as well as an expansion of its collaboration with Biogen first announced in 2015.
Industrials	**PSE**	PSE technologies enable high-fidelity predictive modelling software, and model-based engineering and innovation services for the process industries. In April 2017 the company joined forces with the food & nutrition contract research organisation NIZO to form the Centre of Excellence for Food Product and Process Modelling.

TABLE 6: Startups in the White City Incubator July 2017

Sector	Startup	Business
Pharma & Biotech	**Pulmocide***	Inhaled anti-infectives for targeted treatment of life-threatening lung infections
	MiNA Therapeutics	Gene activation mechanisms through small activating RNA
	senzer	Adjuvant therapies to help alleviate the side effects of cancer and chronic pain
	Therapeutic Frontiers*	Human rhinovirus experimental infection model for the studies in human asthma and COPD
Medical Devices	**MediSieve**	Drug-free malaria treatment using magnetic blood filtration
	SD	Realising the potential of photonics and machine learning in clinical diagnostics
Industrials	**Hexcell***	Thermo-hydraulic fouling predictions for heat exchangers
	Axitan	Veterinary vaccines and peptides from microalgae
Basic Materials	**Polymateria**	Biodegradable, recyclable, customizable and cost-effective plastics, beating global pollution

(indicates an affiliation with Imperial through IP)*

CORPORATE PARTNERSHIPS

Imperial corporate partners engage to access ideas from College discoveries, and future talent in the form of graduates, PhD students and researchers. In 2016-17 Imperial continued to collaborate at scale in research partnerships with many of the world's leading technology companies.

Corporate partnership projects are based on a range of models: a one-year exploration of a particular idea, or a shorter proof of concept with a postdoc; sponsorship of a PhD student; support for multi-year centres and institutes with the capacity to pursue multiple themes; and consortia that pool funding from multiple partners to explore pre-competitive fields.

Every engagement is defined in advance through agreements that set out clear expectations, underpinning motivations, and terms related to funding, publications rights and use of IP. Imperial measures the success of corporate partnerships through scale, the propensity for companies to return for repeat engagement, and the value that generated for partners.

New research contracts

In 2016-17 Imperial signed new contracts with 120 corporate partners, worth £49m. Distribution of award value indicates strong engagement from the Pharma & Biotech sector, together with Aerospace & Defence (Figure 5, page 17). The remaining distribution shows significant scale across ten further sectors, reflecting the widespread appeal of Imperial's academic base, and the reach of its work. Twelve corporate partners funded over £1m each, with 11 of them having engaged in earlier research collaborations with Imperial. Such retention of partners and repeat engagement is a solid reflection on the ability of Imperial academics to deliver long-term value. Notable examples include the AstraZeneca-Imperial College Innovation Fund, the Jaguar Land Rover Centre of Excellence for Spark-Ignition, and the Smith and Nephew collaboration in Biomechanics.

CASE STUDY: Innovation funding

In July 2017 Imperial announced a new partnership with the research-based biopharmaceutical company AstraZeneca to lay the foundations for new medical breakthroughs and publications in leading journals. The collaboration will see the College foster closer links with industry, with researchers from multiple faculties working with AstraZeneca scientists to explore new avenues of fundamental research.

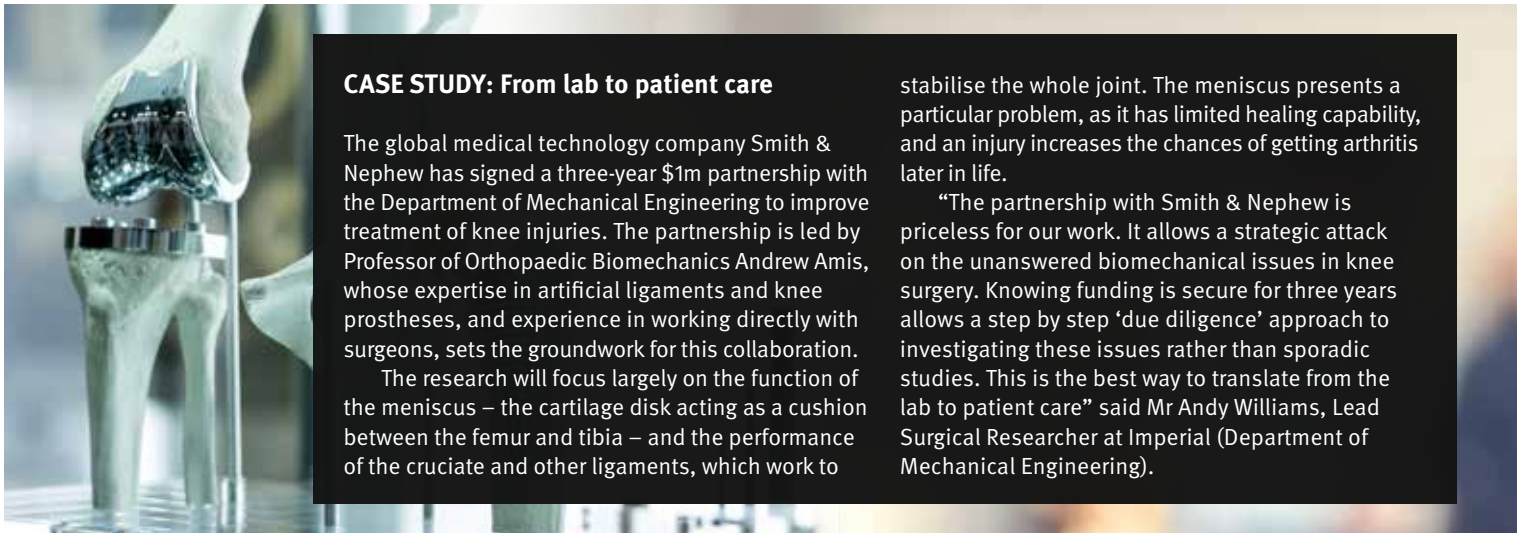
The pharmaceutical firm will provide £1m over five years through the AstraZeneca–Imperial College Innovation Fund to support early-stage research across a number of areas, including treatments for cancer, chronic coughing and male infertility. AstraZeneca will also provide funding for two research fellows per year from 2018.

CASE STUDY: Further support for a Centre of Excellence

In January 2017, Jaguar Land Rover (JLR) resumed the Centre of Excellence for Spark-Ignition Engine Combustion Research at Imperial for five years. The Centre was originally established at University College London in 2013, led by Professor Pavlos Aleiferis. In 2016, he was appointed to Chair in Thermofluids in Imperial's Department of Mechanical Engineering, so the Centre moved to Imperial.

The Centre will continue to form an integral component of JLR's commitment to producing fuel-efficient powertrain technologies. Findings will help to deliver the company's ambitious goal of a 25% reduction in CO2 emissions by 2020 to comply with governmental policy and consumer demand.

Professor Aleiferis commented: "One of the main advantages of having the Centre at a university is that it can respond to questions and needs that are of direct benefit to on-going product development, as well as conducting longer term basic research and training PhD students. This strengthens our scientific understanding for academic excellence but also has direct industrial impact via expert knowledge transfer, as well as great societal benefits via improved quality of life in a greener future environment."



CASE STUDY: From lab to patient care

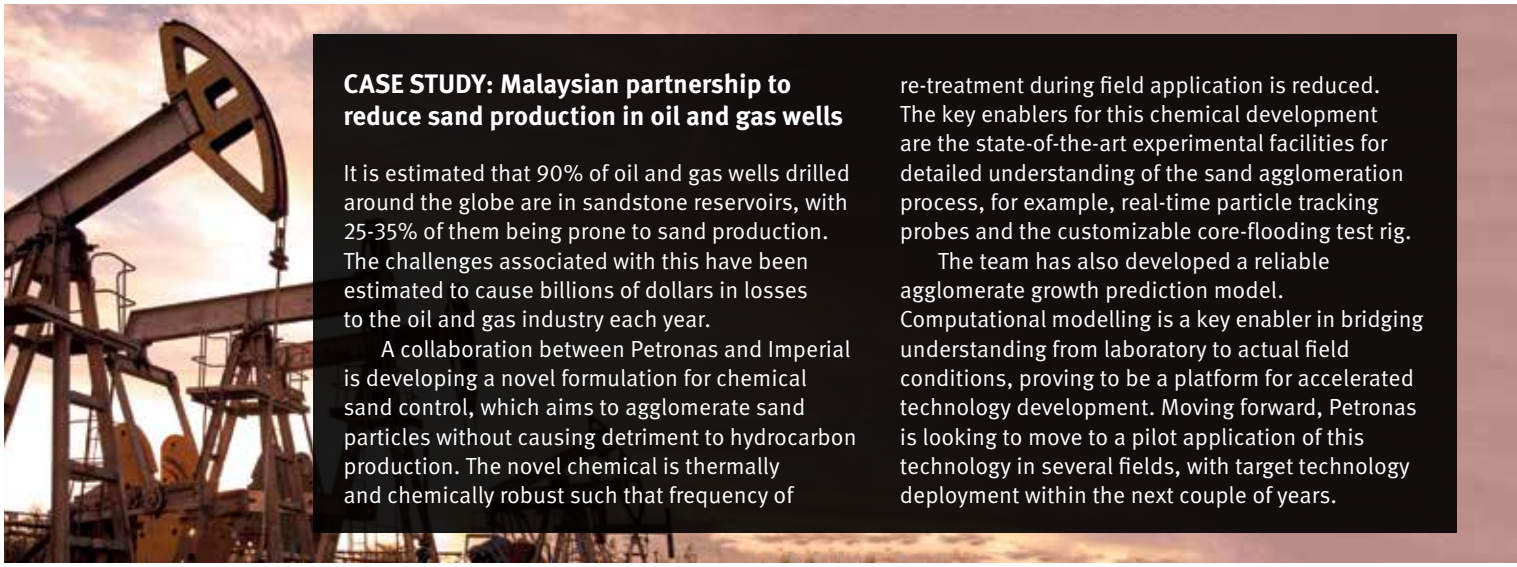
The global medical technology company Smith & Nephew has signed a three-year $1m partnership with the Department of Mechanical Engineering to improve treatment of knee injuries. The partnership is led by Professor of Orthopaedic Biomechanics Andrew Amis, whose expertise in artificial ligaments and knee prostheses, and experience in working directly with surgeons, sets the groundwork for this collaboration.

The research will focus largely on the function of the meniscus – the cartilage disk acting as a cushion between the femur and tibia – and the performance of the cruciate and other ligaments, which work to stabilise the whole joint. The meniscus presents a particular problem, as it has limited healing capability, and an injury increases the chances of getting arthritis later in life.

"The partnership with Smith & Nephew is priceless for our work. It allows a strategic attack on the unanswered biomechanical issues in knee surgery. Knowing funding is secure for three years allows a step by step 'due diligence' approach to investigating these issues rather than sporadic studies. This is the best way to translate from the lab to patient care" said Mr Andy Williams, Lead Surgical Researcher at Imperial (Department of Mechanical Engineering).

International reach

Imperial signed new awards with corporate partners from 22 countries in 2016-17 (Figure 6, page 17). Approximately 33% of the 2016-17 research awards by value were made by UK head-quartered corporate partners; 25% originated from the US; and 13% came from China. Examples include the HNA Research Centre for Future Data Ecosystems (China), the Petronas project in multi-phase fluid dynamics (Malaysia), and the Mitsubishi Heavy Industry Turbocharger Research Programme (Japan).



CASE STUDY: Malaysian partnership to reduce sand production in oil and gas wells

It is estimated that 90% of oil and gas wells drilled around the globe are in sandstone reservoirs, with 25-35% of them being prone to sand production. The challenges associated with this have been estimated to cause billions of dollars in losses to the oil and gas industry each year.

A collaboration between Petronas and Imperial is developing a novel formulation for chemical sand control, which aims to agglomerate sand particles without causing detriment to hydrocarbon production. The novel chemical is thermally and chemically robust such that frequency of re-treatment during field application is reduced. The key enablers for this chemical development are the state-of-the-art experimental facilities for detailed understanding of the sand agglomeration process, for example, real-time particle tracking probes and the customizable core-flooding test rig.

The team has also developed a reliable agglomerate growth prediction model. Computational modelling is a key enabler in bridging understanding from laboratory to actual field conditions, proving to be a platform for accelerated technology development. Moving forward, Petronas is looking to move to a pilot application of this technology in several fields, with target technology deployment within the next couple of years.

Deep partnerships

For a select group of partners, Imperial delivers value across multiple modes of engagement, creating deep partnerships that take advantage of the College's many sources of ideas and talent. One such partnership is the College's partnership with Shell, which involves over 270 people and incorporates nine academic departments, five Shell–Imperial Centres and Labs, and five Shell Chairs. In 2016, 20 Imperial graduates were recruited by Shell, retaining Imperial's position in the top two global sources of graduate hires.

CASE STUDY: Long-term collaboration

The Shell–Imperial Advanced Interfacial Materials Science (AIMS) Centre was launched in March 2016 to improve our understanding of how materials behave, with the long-term goal of making industrial processes safer, more predictable and more efficient, ultimately resulting in better asset management and operational performance.

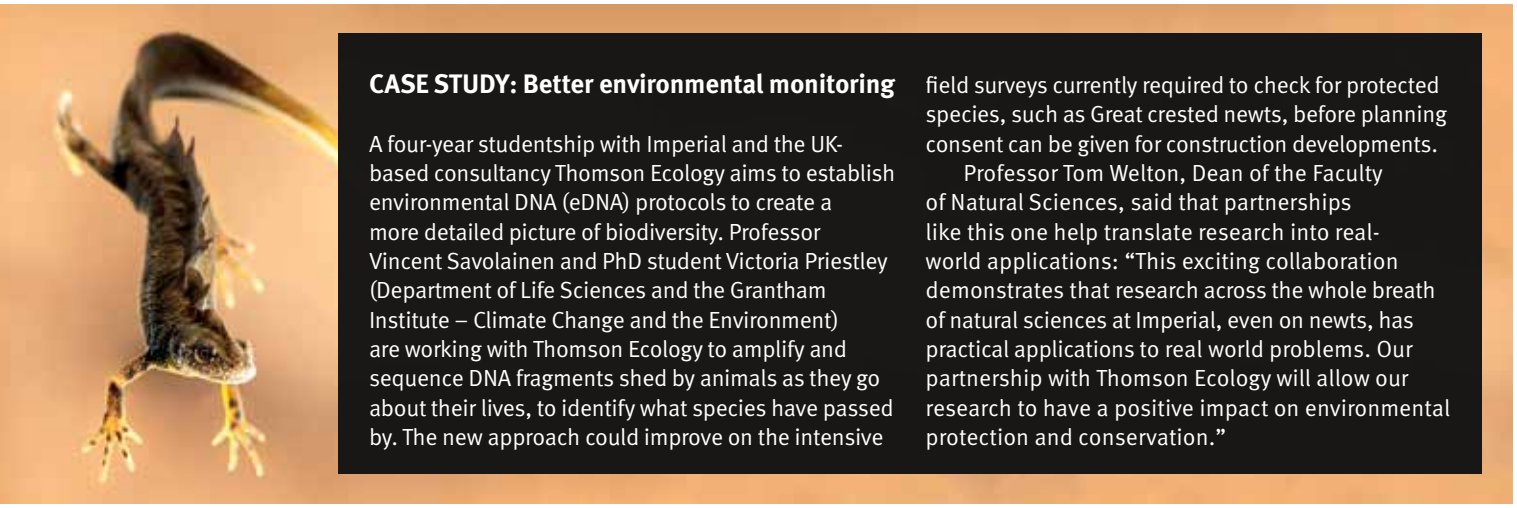
AIMS is based in the Department of Materials and led by Professor Mary Ryan. It was established as a result of a synergistic, ongoing partnership between Shell's Materials and Corrosion R&D team, and Imperial's Department of Materials. Professor Ryan also currently holds the Shell/Royal Academy of Engineering Chair in Interfacial Nanoscience for Engineering Systems.

"We are providing enhanced materials capabilities across the range of business units within Shell; both in their core and developing areas," Professor Ryan commented. "The Centre is founded on the strong relationship between Imperial and Shell and a great advantage of our programme is the ability to work closely with our technical colleagues within Shell, exchanging knowledge and gaining real insights into operational materials challenges."

The Centre forms one more facet to the longstanding Shell–Imperial relationship with ongoing work at the Sustainable Gas Institute, the fuels and lubricants University Technology Centre, the Digital Rocks Lab, and the Qatar Carbonate and Carbon Storage Research Centre (sponsored by the Qatar Science and Technology Park, Shell and Qatar Petroleum).

Engaging with small and medium size enterprises (SMEs)

Supporting and accelerating SMEs is a key factor in driving economic growth. Imperial has long-standing relationships with SMEs across a range of sectors, and continues to seek ways of establishing structured relationships with more of them.



CASE STUDY: Better environmental monitoring

A four-year studentship with Imperial and the UK-based consultancy Thomson Ecology aims to establish environmental DNA (eDNA) protocols to create a more detailed picture of biodiversity. Professor Vincent Savolainen and PhD student Victoria Priestley (Department of Life Sciences and the Grantham Institute – Climate Change and the Environment) are working with Thomson Ecology to amplify and sequence DNA fragments shed by animals as they go about their lives, to identify what species have passed by. The new approach could improve on the intensive field surveys currently required to check for protected species, such as Great crested newts, before planning consent can be given for construction developments.

Professor Tom Welton, Dean of the Faculty of Natural Sciences, said that partnerships like this one help translate research into real-world applications: "This exciting collaboration demonstrates that research across the whole breath of natural sciences at Imperial, even on newts, has practical applications to real world problems. Our partnership with Thomson Ecology will allow our research to have a positive impact on environmental protection and conservation."

Novel modes of engagement

Imperial continues to innovate in the way it engages with corporate partners, seeking new ways to unlock value from collaboration. Two recent examples are Apollo Therapeutics, and the Hackathon process established by Imperial College Advanced Hackspace.

CASE STUDY: Innovative funding

Apollo Therapeutics was established in January 2016, and has access to £40m funding to provide Imperial academics and partners with new opportunities to drive forward therapeutic innovation. Apollo is a joint venture between AstraZeneca, GlaxoSmithKline, Johnson & Johnson, and the technology transfer offices of Imperial, University College London and the University of Cambridge. These work with Apollo's drug discovery skills and funding to translate outstanding academic science into innovative new medicines across a wide range of disease areas and drug modalities.

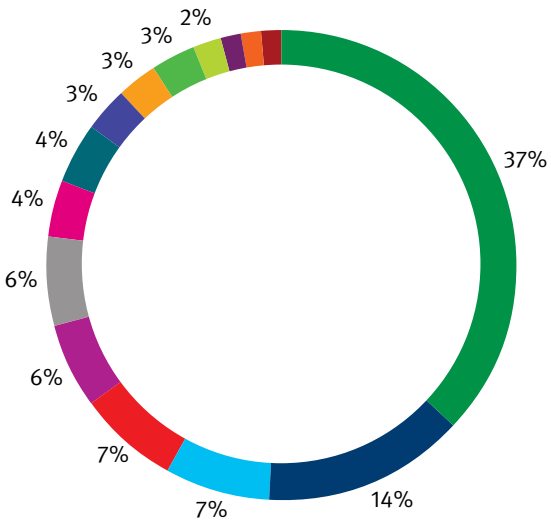
By the end of July 2017, Apollo had committed £14m to initial projects. Imperial projects approved in year include small molecule and monoclonal antibody discovery programmes for treating pulmonary arterial hypertension with Professors Martin Wilkins and Lan Zhao (Department of Medicine); and a programme to identify drug-like, substrate-selective LTA4H inhibitors for inflammatory diseases with Dr Robert Snelgrove (National Heart and Lung Institute).

CASE STUDY: Convening creativity

The BP Imperial Hackathon in July 2017 brought together engineers, scientists, developers, designers, entrepreneurs and hardware hackers to come up with innovative ideas to connect BP with its customers through voice-activated technology. Participants included student, alumni and staff.

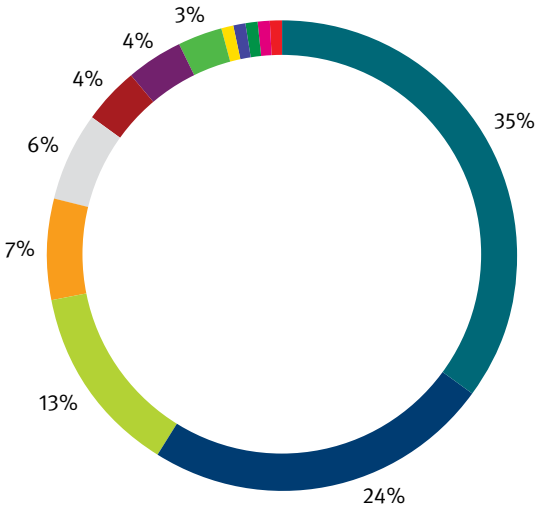
The launch included talks from BP, Amazon Web Services and Imperial College Advanced Hackspace (ICAH). The Hackathon continued over the weekend in ICAH's new space at the Invention Rooms on Imperial's White City campus. The Best in Show Prize went to the team behind Snack Overflow – an innovative use of voice-activated technology to diagnose maintenance issues with your car. The Customer Experience Prize was won by Vox-way – a system to connect groups of people travelling in separate cars. The Technology Prize was won by Connect the Dots, which used voice-activated technology with CCTV to help petrol station managers improve safety. The Innovation Prize was won by The Rubber Ducks, which developed voice-activated technology to stop drivers falling asleep at the wheel.

FIGURE 5: Distribution of 2016-17 contract awards with corporate partners by sector



- Pharma & Biotech
- Aerospace & Defence
- Basic Materials
- Energy
- Industrials
- Travel & Leisure
- Financials Services
- Automotive
- Food & Nutrition
- Medical Devices
- Technology
- Telecoms
- Healthcare Providers (1%)
- Personal Care (0.74%)
- Consumer (0.69%)
- Utilities (0.43%)
- Media (0.42%)

FIGURE 6: Distribution of award value by global headquarters of corporate partner

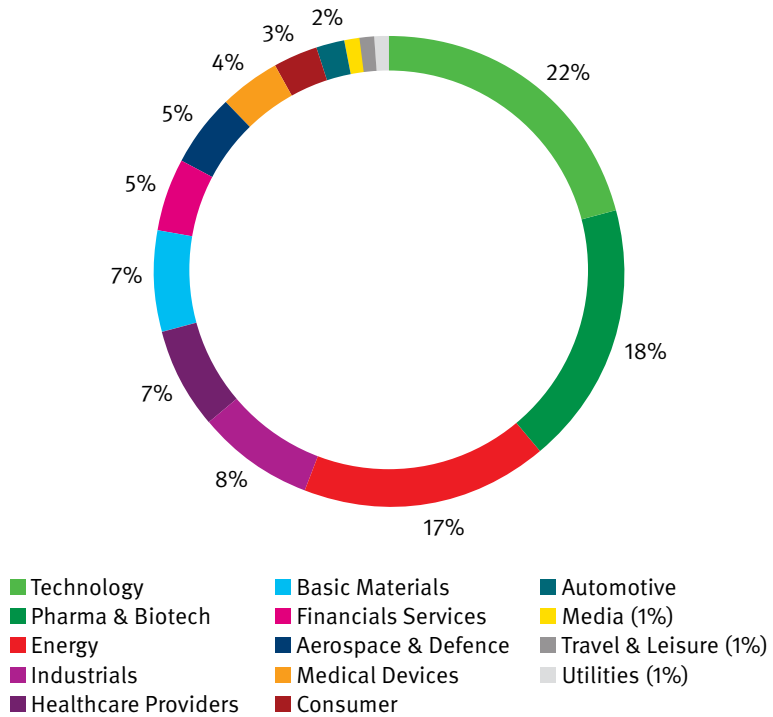


- UK
- US
- China
- Germany
- Belgium
- Switzerland
- Japan
- Denmark
- India (0.94%)
- Malaysia (0.80%)
- Finland (0.57%)
- South Korea (0.57%)
- Spain (0.57%)
- Canada (0.48%)
- Italy (0.30%)
- UAE (0.29%)
- France (0.28%)
- Australia (0.05%)

CONSULTANCY

Imperial Consultants works to solve the needs of industry, government and the third sector by harnessing the expertise of its research-active academics and facilitating access to Imperial facilities and equipment. In the reporting year, Imperial Consultants initiated 366 new projects for 283 clients from all industry sectors (Fig. 8). Clients were based in the UK and abroad, with 32% of clients coming from 29 countries outside the UK. Projects were completed by academics across the College, led by 220 experienced Principal Investigators.

FIGURE 7: Imperial Consultant projects by sector 2016-17



CASE STUDY: Informing the debate on Britain's electricity

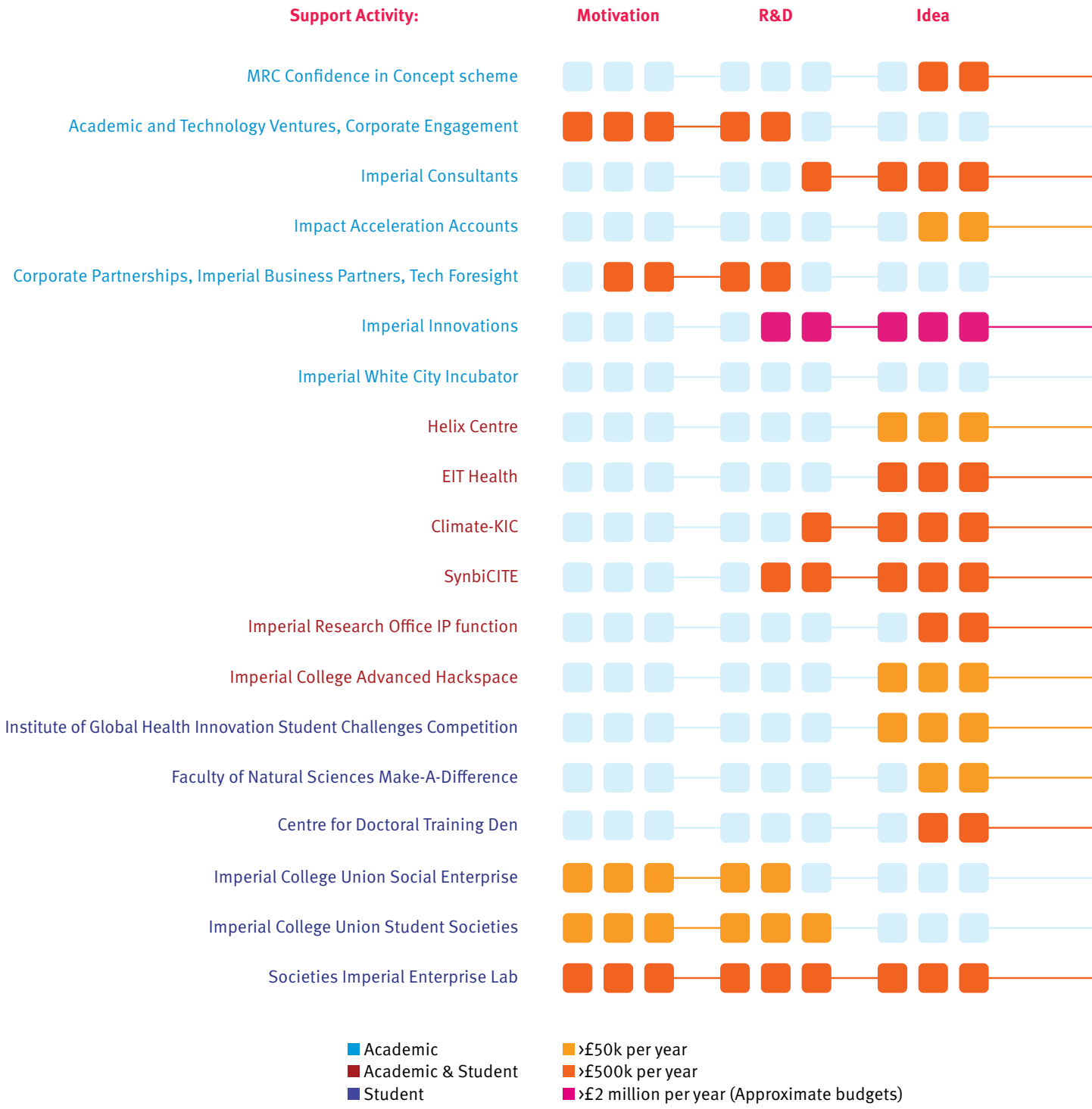
The electricity sector is currently undergoing unprecedented changes, including obligations to decarbonise and pressure to keep bills down. With old coal being driven off the system, new nuclear given the go-ahead, prices reaching new highs and lows, and clean energy overtaking fossil fuels for the first time, there is an increasing need for a strong evidence base and robust analysis.

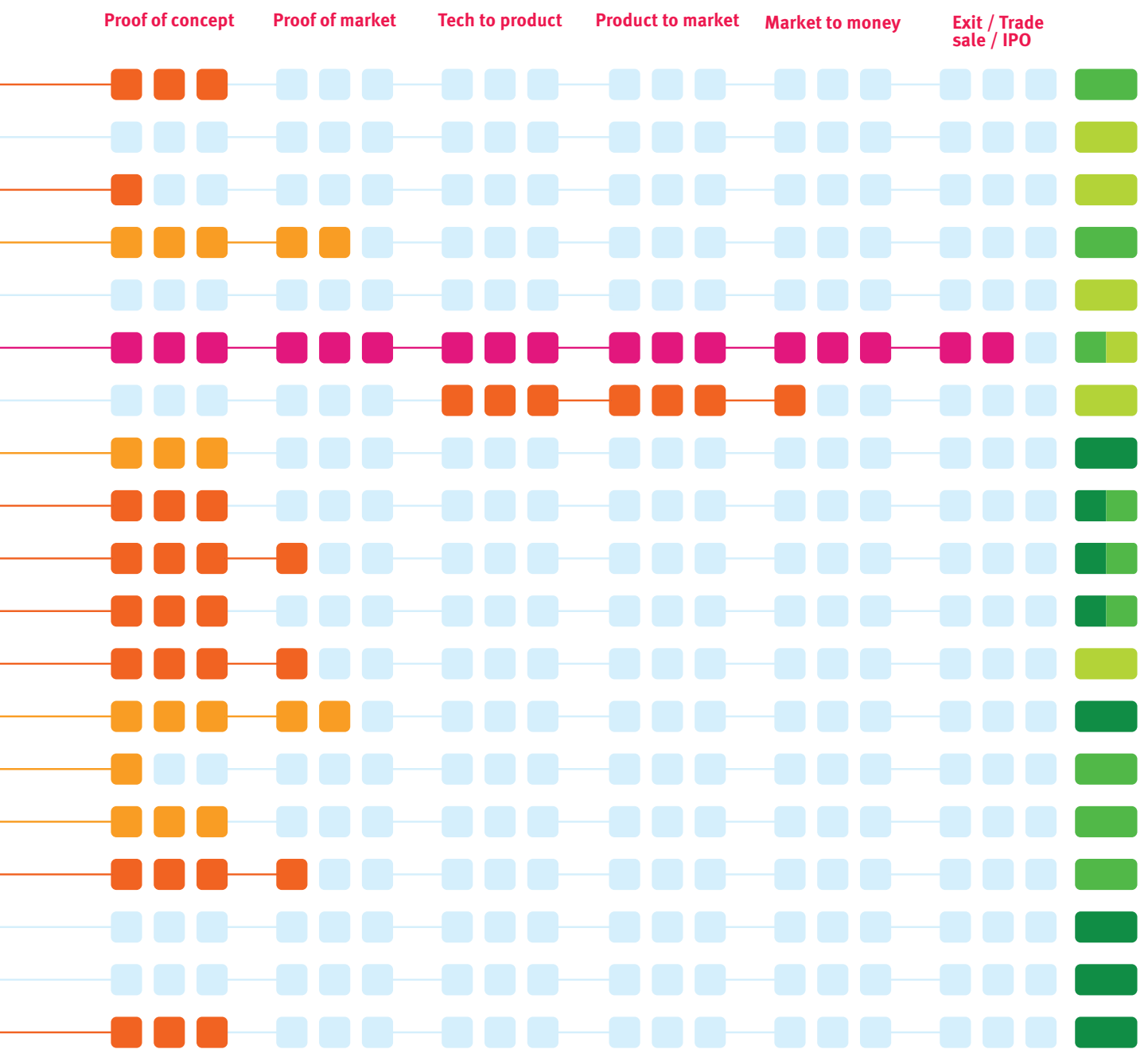
Imperial researchers, including Drs Iain Staffell and Rob Gross (Centre for Environmental Policy) and Professors Richard Green (Imperial Business School) and Tim Green (Director of the Energy Futures Lab), are providing new empirical evidence to contribute to the UK energy debate. Commissioned by Drax Group, operator of the UK's largest power station, based at Selby in North Yorkshire, which now predominantly uses sustainable biomass to generate 17% of the UK's renewable electricity, the Imperial team is using its combined analytical expertise to power www.electricinsights.co.uk, an interactive website and quarterly report.

Electric Insights brings to life the wealth of raw data made publicly available by National Grid and Elexon, which run the electricity network and balancing market respectively. Using information gathered from 2009 to present day, it focuses on supply and demand, prices, emissions, the performance of the various generation technologies and the network that connects them. The website and reports are regularly referred to in the press and shed an informative light on the sources and implications of Britain's electricity supply for both government and the industry.

SUPPORT ACTIVITIES MAPPED ACROSS TYPICAL ENTREPRENEUR'S JOURNEY

This diagram was developed to map Imperial's entrepreneurial ecosystem. It highlights the schemes, programmes, centres and other activities at the College designed to support staff and students at different stages of their entrepreneurial journey.




Proof of concept
Proof of market
Tech to product
Product to market
Market to money
Exit / Trade sale / IPO
Organisations that help bring entrepreneurs together
Funding sources that support innovation
Support functions

Imperial College Inventive Output Scorecard YE 2016-17

Metric	2012-13	2013-14	2014-15	2015-16	2016-17
Inventive Output					
Inventions disclosed	306	323	296	310	332
Patent applications filed	43	57	66	73	68
Patents issued	78	98	47	59	40
Active inventions in portfolio	832	977	1,007	1,021	1,009
Active patents in portfolio	325	373	394	404	429
Licensing Performance					
New licenses signed	29	27	39	39	46
Active licenses held	170	175	193	202	217
Licenses generating income in the period	48	71	74	70	91
Royalty and fee income generated in the period (£m)	£1.3	£1.6	£2.8	£2.1	£3.0
Startup Formation					
IP-based startups formed	5	7	8	6	9
Student-based startups formed	6	8	18	16	16
Incubation Performance					
Startups housed by university incubators	18	16	18	13	9
Startups graduated from an incubator program	2	2	2	4	10
Active incubator graduate companies	13	15	17	21	31
Startup Investment					
Investment funding acquired by IP startups (£m)	£26	£254	£363	£114	£124
Investment funding acquired by Student startups (£m)	£0.5	£0.8	£4.5	£8.4	£1.1
Startup Companies Performance					
IP startups still active	71	73	74	70	76
Jobs supported directly by IP startups	490	645	814	1,002	974
Student startups still active	7	14	29	44	60
Jobs supported directly by Student startups	98	163	252	305	342
Realisation income from sale of shares in IP startups (£m)	£0.4	£-	£1.9	£1.6	£6.4
Ratios					
Research income (£m)	£330	£351	£436	£351	£361
Invention disclosures per £100m of research income	93	92	68	88	92
Patents filed per £100m research income	13	16	15	21	19
Patents issued per £100m research income	24	28	11	17	11
Licensing and realisation income : research income (%)	0.5%	0.4%	1.1%	1.1%	2.6%
IP startups per £100m research income	1.5	2.0	1.8	1.7	2.5
Student startups per £100m research income	1.8	2.3	4.1	4.3	4.4

KNOWLEDGE EXCHANGE AND TECHNOLOGY TRANSFER AT IMPERIAL

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