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Microbiome Ireland
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Executive Summary

APC Microbiome Ireland

15 years of impact

mining microbes for mankind



"Research institutions in the modern world must increasingly demonstrate both scientific and economic impact. The report here demonstrates that APC Microbiome Ireland achieves these twin impacts, convincingly. It goes beyond these indeed, showing social impact.

The economic impact analysis is thorough, using at its core a long established and widely accepted methodology. The report is comprehensive – it captures all the direct, indirect and knock-on (induced) impacts of the activities of APC Microbiome Ireland. The analysis illustrates the significant economic and employment impact that the institute has on an ongoing basis, showing the very positive net addition to both economic wealth and employment which APC Microbiome Ireland has had on the local and national economy.

This report underlines the importance of investing in research through national institutes of this calibre and size. In my view APC Microbiome Ireland is an economic, scientific and research success story and an endorsement of the SFI funding approach which allowed it to grow and expand."

Professor Brian Lucey, Trinity College Dublin, External Reviewer

Contents

Introduction	3
At a Glance	4
Economic Impact	6
Scientific Impact	8
Human Capital Impact	10
Societal Impact	12
Case Studies	15

APC Microbiome Ireland **15 years** of impact

Introduction

APC Microbiome Ireland has reached its **15th birthday**, a time to celebrate, a time to consider the future and a time to assess the growing impact of APC.

Ambitious, dynamic, transdisciplinary, APC Microbiome Ireland (APC) is a flagship Science Foundation Ireland (SFI) Research Centre…and much more. It is a global leader in microbiome science and an agent of change. From the outset the APC has adhered to its mission: 'Linking Irish science with industry and society through excellence in research, education and public engagement in gastrointestinal health'. Impact has been wide-ranging and includes economic growth, development of human skills, scientific and medical discovery with translation to new medical and dietary therapy, public health policy, and societal engagement.

APC investigates the microscopic organisms (microbes) that live in and on the body in health and disease. This community of microbes (microbiota) includes bacteria, yeasts and viruses which are beneficial and necessary for optimal human development but may occasionally represent a risk for development of disease in susceptible individuals. APC has pursued three main lines of scientific pursuit: firstly, to develop **new diagnostics or biomarkers** of health or risk of disease based on analysis of the microbiota; secondly, to explore **mechanisms** by which the microbiota may be favourably mobilised or manipulated; and thirdly to '**mine**' the microbiota for new drugs and/or functional food ingredients. In addition to research, APC trains the next generation of scientists to become the industry and academic leaders of tomorrow.

APC encourages the general public, including students from 1st to 4th level, to think scientifically and to engage in scientific debate of societal relevance.

Since its foundation in 2003, APC has leveraged four successive phases of seed funding from SFI to attract additional investment from industry collaborators and funding sources including the European Union, and philanthropy. Simply stated, for every €1 of core investment by SFI, the APC has realised an additional €1.84 externally. This multiplier effect – a doubling of taxpayer investment – is a rarity in any field of public endeavour. Indeed, when economic hardship struck Ireland a decade ago, our scientists delivered and APC flourished.

This report is an acknowledgement of government support for research and human capital development. It is testimony to the achievements of a dedicated group of scientists, and provides an overview of the economic, scientific, human capital and societal impacts of APC Microbiome Ireland. We intend it to serve as a benchmark for the future.

Professor Fergus Shanahan, Director
December 2018

15 impacts *for 15 years*

APC is ranked as a

global leader

#1 worldwide for research in anti-microbials and therapeutic microbes

APC helps to support

526 jobs

in Ireland each year

APC helps to generate

€1.2 million

for the Irish Economy each week, including expenditure and taxation impact

In 2018, 10 APC Principal investigators were ranked in the

Top 1%

of researchers worldwide

APC is a flagship SFI Research Centre which expands the R&D capabilities of Ireland Inc.

To date APC researchers have won over

€200 million

in competitive funding

APC is a leader in

knowledge generation and transfer

APC researchers have authored more than 2,500 publications which have been cited more than 80,000 times

APC

commercialises its knowledge

successfully

APC inventors have filed 54 new patent applications, and signed 47 license, assignment and option agreements

APC researchers have secured over

€50million

in R&D funding from industry

for collaborative research projects

APC has a

global reach

attracting top international talent to Ireland - APC staff are drawn from ***36 different countries*** *world-wide*

APC has produced 973 internationally co-authored publications with authors from 59 countries

APC researchers have

spun-out 3 companies

employing 51 people, generating approximately €6.6m in economic activity annually and attracting at least €10m in inward investment

APC has trained

550 alumni

who have advanced to positions in academia, industry and the health care sector across the globe

For every €1 invested by SFI, APC has added another €1.84 of

inward investment

50% of which is from non-exchequer sources

€5.60 return

to the economy for every €1 State investment in APC

Taking 2017 as a representative year, APC produced €65.4m in output from an input of €11.7m State investment

APC has a vigorous public engagement programme

APC researchers have presented science to over 50,000 school students and almost 100,000 children have passed through the APC inflatable Alimentary Adventures tunnel of the human gut at public events. APC has co-ordinated 350 Transition Year student placements

APC research has immediate relevance to

public health

such as antimicrobial resistance, obesity, mental health, successful ageing, and inflammatory diseases

Economic *Impact*

Taking 2017 as a representative year, the total economic impact of APC is €65.4m per annum, meaning that **APC helps generate €1.2m per week for the Irish economy.**

The impact generated by expenditure is €58.8m annually and the fiscal contribution including taxes and social insurance contributions amounts to a further €6.6m. That is a return of €5.60 to the Irish economy for every €1 of State (SFI) investment in APC. This compares favourably with the Leading European Research Universities (LERU Group)[1], whose return is estimated at €5 for every €1 invested.

APC has won competitive grants from SFI of €72.8m since 2003, and has added to this by winning another €133.3m in research funding from Industry, Exchequer, EU and philanthropic sources. Since its inception, total inward investment in APC has exceeded €206m. **For every €1 invested by SFI, APC has added another €1.84 in matched investment.**

[1] Leading European Research Universities (LERU). The Economic Contribution of LERU universities 2016, published December 2017





APC has attracted **foreign direct investment from 11 companies** that would not otherwise have a footprint in Ireland were it not for the APC research.

APC research has led to 47 technology licence, option and assignment agreements with **the potential to realise €1.1m in licencing income**, in addition to royalties on sales. In the last five years, APC has signed 53 collaborative research agreements with industry partners in the pharmaceutical, biotechnology, and food sectors.

In the last 5 years, the APC has signed 13 collaborative research agreements with **Irish companies**, and 4 license agreements with **Irish SMEs**. These interactions enhance the R&D portfolios of these Irish companies, and potentially lead to development of new products that will boost sales and secure jobs in Ireland.

APC has **spun out 3 companies that employ 51 people currently** and have secured at least **€10m in inward investment**. Furthermore, they help generate an estimated additional €6.62m in economic activity each year.

APC **supports 526 jobs in Ireland**, across all sectors.

In 2018, the APC hosted 2 international conferences with over 900 international delegates, which had an estimated **positive impact on the Irish and local economy of €1.4m.**

Scientific *Impact*

10 APC Principal Investigators were on the Clarivate Analytics **2018 Highly Cited Researchers** list of the 1% of scientists who are most highly cited by their peers.

APC has produced over **2,500 publications** which have been cited **>81,000 times**, equating to over 32 citations per paper. 40% of these APC publications were from international collaborations, with co-authors based in 59 different countries.

Bibliometric analysis of APC publications completed by CWTS Leiden reported the following:

- APC is **ranked # 1 globally** in the fields of anti-microbial research and probiotics
- APC is in the **top 5 Institutions** in the world for microbiome research
- 25% of APC papers are among **top 10% mostly frequently cited** papers globally
- In the 2010-2014 period, the citation score for APC papers was **>2.5 world average**
- APC papers with **industry co-authors** had the highest normalised citation impact





APC PIs have received **155 significant distinctions and awards**, including the RIA Gold Medal for Research to Fergus Shanahan, the University of Utrecht Award for Pharmaceutical Excellence to John Cryan and the American Dairy Association Award for distinguished service to Paul Ross.

APC **scientific discoveries** include i) Thuricin CD, a potent antimicrobial active against *Clostridium difficile*, ii) a microbiome-based diagnostic test for colorectal cancer and iii) a new understanding of elderly nutrition based on the concept that diversity of diet promotes microbiota diversity and reduces inflammatory and other age-related disorders.

APC's world-leading research programme in novel anti-microbials led to the foundation of **Artugen Therapeutics**, while **Tucana Health** (acquired by 4D Pharma plc) was established based on know-how arising from the APC's microbiome diagnostics programme.

54 new patent applications have been filed by the APC based on APC scientific discoveries, **with 12 patents granted** to date. APC publications have been cited in 128 different patent families, showing how APC research is broadly informing the development of new microbiome-based technologies globally.

Human Capital *Impact*

APC has trained 550 alumni who have advanced to positions in academia, industry and the healthcare sector across the globe.

25% of APC alumni have moved to industry as a first destination, with half to companies in Ireland, improving corporate absorptive capacity to adopt science-based innovations.

APC has taken a leading role nationally to develop the **next generation of science leaders** - it supports early career researchers through undergraduate summer bursaries, summer schools, PhD programmes, APC-Imperial College London PhD workshop exchange, and the Marie Curie COFUND postdoctoral programme.

APC has a **global reach**, and has attracted top international talent to Ireland. **APC researchers come from 36 different countries.**

APC alumni in Ireland **create extra economic value of €5.3 million annually**. This is a significant impact when considered over the lifetime of a professional career.





APC clinicians & research nurses are **fostering a research culture** in the health service to improve healthcare and patient outcomes.

With 63% of our PhDs and postdocs being female, APC is playing its part in **encouraging young women in careers in STEM** (Science, Technology, Engineering and Mathematics), helping to address the gender gap.

In financial terms, **the additional earning potential (output) of an APC postgraduate over their career (€535,240) is almost 11 times the cost** (input) of postgraduate training (€48,749, which includes fees, living costs etc.).

APC research influences the quality of teaching and learning, ensuring that students are informed of cutting edge science about the influence of the microbiome on health.

Societal *Impact*

APC is at the forefront of good medical practice. APC was instrumental in introducing faecal microbiota transplantation (FMT) to Irish hospitals for recurrent *Clostridium difficile* infection.

APC research led to the introduction of low-radiation CT scanning in clinical practice. Microbiome screening of lung samples from people with cystic fibrosis has helped in the rapid identification of disease-causing pathogens and personalised antimicrobial treatment.

APC authored an EU Whitepaper on microbiome which is helping to shape a new EU microbiome research initiative.

APC has an unparalleled public engagement programme, consistently promoting science awareness and understanding. **APC researchers interact with approx. 80,000 members of the public each year** through school visits, visits to APC labs, public fora, and science fairs – in 2017 APC staff gave 51 public lectures, carried out 103 school visits and had 390 media interactions.

APC research has helped to raise public awareness of a health risk or benefit. For instance, APC research has raised awareness of the effects of C-section delivery on the gut microbiota and the particular benefits of breastfeeding infants born by C-section.





APC has a tradition of promoting diversity and inclusion. From 'real' research engagement through interdisciplinary projects such as interactions with DEIS schools from underprivileged areas, and a dedicated research project to explore the impact of the Traveller community lifestyle on the gut microbiome and general health.

APC researchers engaged with **Irish and European regulatory authorities** regarding new therapeutic approaches, such as bacteriophage, FMT and received confirmation that bioengineered nisin derivatives can be used as non-genetically modified biopreservatives.

APC has a focus on youth, ranging from the placement of 350 transition year students at APC, to more than 50,000 school students. APC's website targeted toward children, Microbemagic.ucc.ie, has approx 500,000 hits annually.

APC has organised 15 public fora since 2013 attended by over 3,000 people including "Gut Health, Fitness and Performance", "Microbes Matter" , and "Super Bugs: Friends and Foes".

APC has a long history of patient engagement, directly through clinicians and also through charities, such as patient days with the Irish Society for Colitis and Crohn's disease. This has promoted increased interest in APC research, and has resulted in full participation in APC clinical studies.



"Artugen Therapeutics Ltd is a start-up company founded in 2015 based on expertise from APC Microbiome Ireland. It is based in Cork, and through a collaboration agreement with the APC, Artugen funds three researchers in UCC. This collaboration with the APC provides Artugen with expertise, lab facilities and access to a wider microbiome research community, which would be very difficult to achieve on our own as a new company. Through our joint work, Artugen and UCC have identified innovative, live biotherapeutics candidates which we are progressing towards clinical evaluation."

Artugen Therapeutics
***Ronald Farquhar**, CEO*

Case Studies

Curiosity-driven Science Discoveries

APC science is structured to satisfy intellectual curiosity whilst maintaining relevance to commercial partners. Examples of disruptive discoveries in three main areas of pursuit are illustrative: *(i) Microbiota as biomarker of health and risk of disease:* APC was first to show that dietary diversity is not solely spice of life, it is staple. Dietary diversity is critical for maintaining microbial diversity, particularly in the elderly. *(ii) Manipulation of Microbiota:* APC has pioneered the therapeutic manipulation of the microbiota with strategies ranging from whole faecal transplantation to the single biotherapeutic strains and bacteriophage. *(iii) Mining the Microbiota:* APC scientists were among the pioneers to show that the microbiota may be mined for new drug discovery including novel antibiotics (eg. Thuricin), new anti-inflammatory molecules, and an epithelial growth factor for mucosal healing.

From Spin-outs to SMEs to Multinationals

APC has seamlessly and effectively supported spinout companies, Irish SMEs and major multinationals, from the food, pharma, animal health and diagnostics sectors.

Atlantia Food Clinical Trials Ltd was spun out of the APC in 2013 to commercialise know-how developed in design and execution of clinical interventions. APC identified an unmet need to support companies to obtain health claims for foods. Atlantia works with most of the major food, beverage and supplement companies worldwide and employs 35 staff. Approximately half of its business is in the USA with the remainder in Europe and Asia.

Alimentary Health Ltd, an Irish healthcare SME, was founded in 1999, in part by APC researchers. It has become a global leader in the discovery, development and commercialisation of precision biotics. The company has a strong record of productive collaboration with APC. The company's lead commercial product - incorporating the probiotic *B. longum* 35624® strain licensed from UCC - is marketed in the US and Canada as *Align®* by the Procter & Gamble company and as Alflorex® in Europe and elsewhere.

Janssen Biotech Inc, one of the pharmaceutical companies of Johnson & Johnson, approached APC in 2015 because it is the only centre that combines expertise in bacteriophage research and the human microbiome. The goal of the collaboration is to explore the potential of natural gut phages as a source of novel diagnostic and therapeutic tools for use in Inflammatory Bowel Disease. The project supports the training of PhD students and postdoctoral scientists and has already yielded important discoveries concerning the role of phages in shaping the gut microbiota, published in high-impact journals. Two additional microbiome-related collaborative projects have since been initiated with Janssen/J&J since 2015.

Danone Nutricia employs 400 people in Ireland, with their north Cork plant supplying 80% of Danone's baby nutrition powder. APC researchers collaborate with Danone Nutricia on genomic, physiological and immunological aspects of beneficial microbes. The financial commitment of Danone to APC projects has exceeded €1 million. The collaborative research has helped Danone design the next generation of infant formula which will be produced at a new manufacturing facility in Cork, creating 40 new permanent jobs. The partnership has also resulted in a patent application, several collaborative scientific publications, and an additional collaboration through an EU project.



"Microbiome science is developing extremely fast with tremendous opportunity for innovation. As one of the pioneers in the field of the microbiome, the APC has significant breadth and depth in microbiome science capability including an impressive track record in the areas of mother-infant and gut-brain axis. This made the APC an ideal partner for DuPont Nutrition & Health's new venture".

DuPont Nutrition & Health. Angela Naef,
Global Technology and Innovation leader

"Kerry has enjoyed an excellent relationship with APC Microbiome Ireland, due to the APC's expertise in prebiotics and on the microbiota. The collaborations (4 projects in the last 5 years) have been very beneficial and are generating data that helps Kerry to make decisions on processes and what products may proceed to market. The technical knowledge/know-how of the various people involved in the APC has been very impressive"

Kerry Group. Cal Flynn,
Research and Development Team

Case Studies

Training Early Career Researchers - European Success for APC

APC has succeeded across the EU's Marie Skłodowska-Curie Actions (MSCA) funding programme, which supports the development of exceptional Early Stage Researchers through training, mentoring and networking actions. An essential requirement is researcher mobility, and the APC has used its global reputation to attract talented international students, postdoctoral researchers and rising stars to APC. APC has succeeded across all areas of the MSCA programme, including COFUND, Individual Fellowships, Innovative Training Networks and Research and Innovation Staff Exchanges, resulting in €4.4 million in competitive EU funding since 2013. A total of 18 postdoctoral researchers and 7 PhD students have been recruited from Europe, Asia, North and South America and Australia, with a further 10 postdoctoral researchers to be recruited in 2019 for two-year fellowships as part of the APC's COFUND.

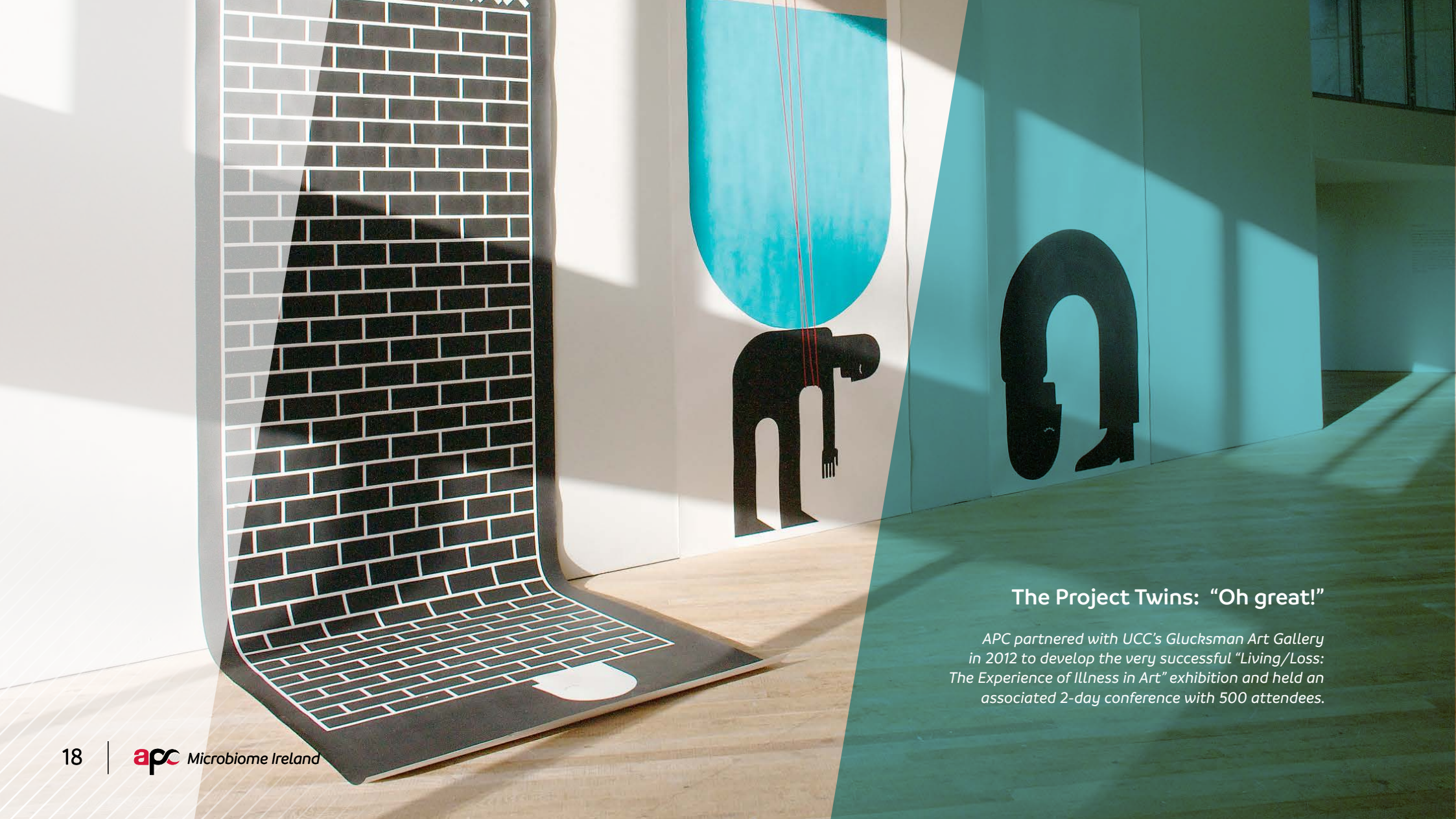
World Microbiome Day

APC launched the hugely successful World Microbiome Day on June 27th 2018 to highlight the importance of microbiomes to human, animal and environmental health and encourage public dialogue. The APC's World Microbiome Day website is replete with information to encourage the protection of microbiomes, and such was its success that the event will become annual.



"AbbVie Inc. really values its strategic research collaboration with APC Microbiome Ireland - a world leading SFI Research Centre - and the opportunity to use their innovative target discovery strategies for the development of more effective treatments for patients with Crohn's Disease (CD). Researchers at the APC have developed new approaches and cutting-edge expertise to study interactions between inflammatory pathways and elucidate novel targets for the treatment of gastrointestinal diseases. This together with Abbvie's global leadership in Immunology and development of novel biologics, small molecules and bispecific antibodies will facilitate the development of potential therapeutic interventions for CD. We are very excited about this collaboration."

Abbvie. Lisa Olson,
Vice President, Immunology Research and Site Head of AbbVie Bioresearch Center Inc.



The Project Twins: "Oh great!"

APC partnered with UCC's Glucksman Art Gallery in 2012 to develop the very successful "Living/Loss: The Experience of Illness in Art" exhibition and held an associated 2-day conference with 500 attendees.

Industry Partners



Microbiome Ireland

Interfacing Food & Medicine

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