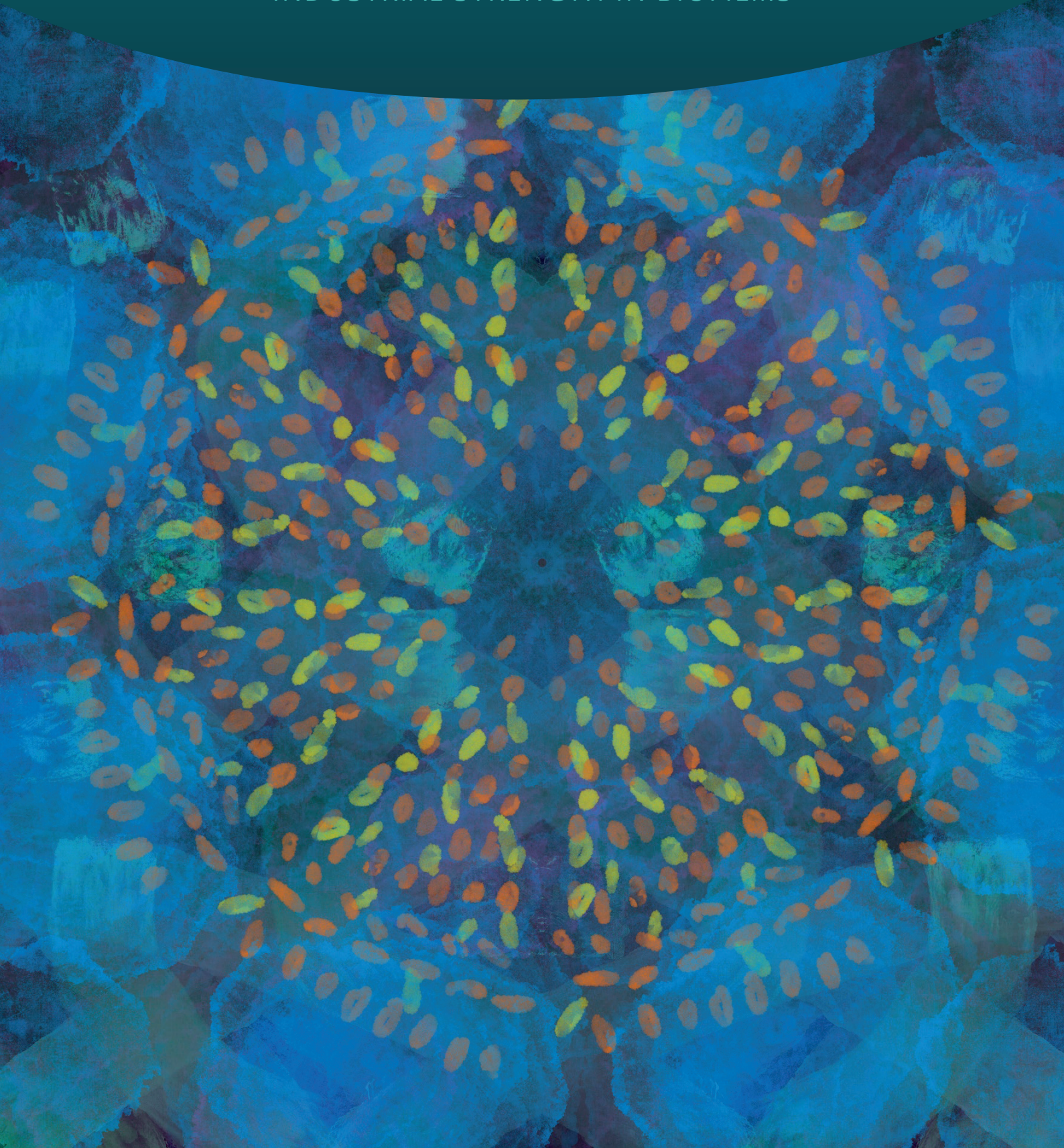
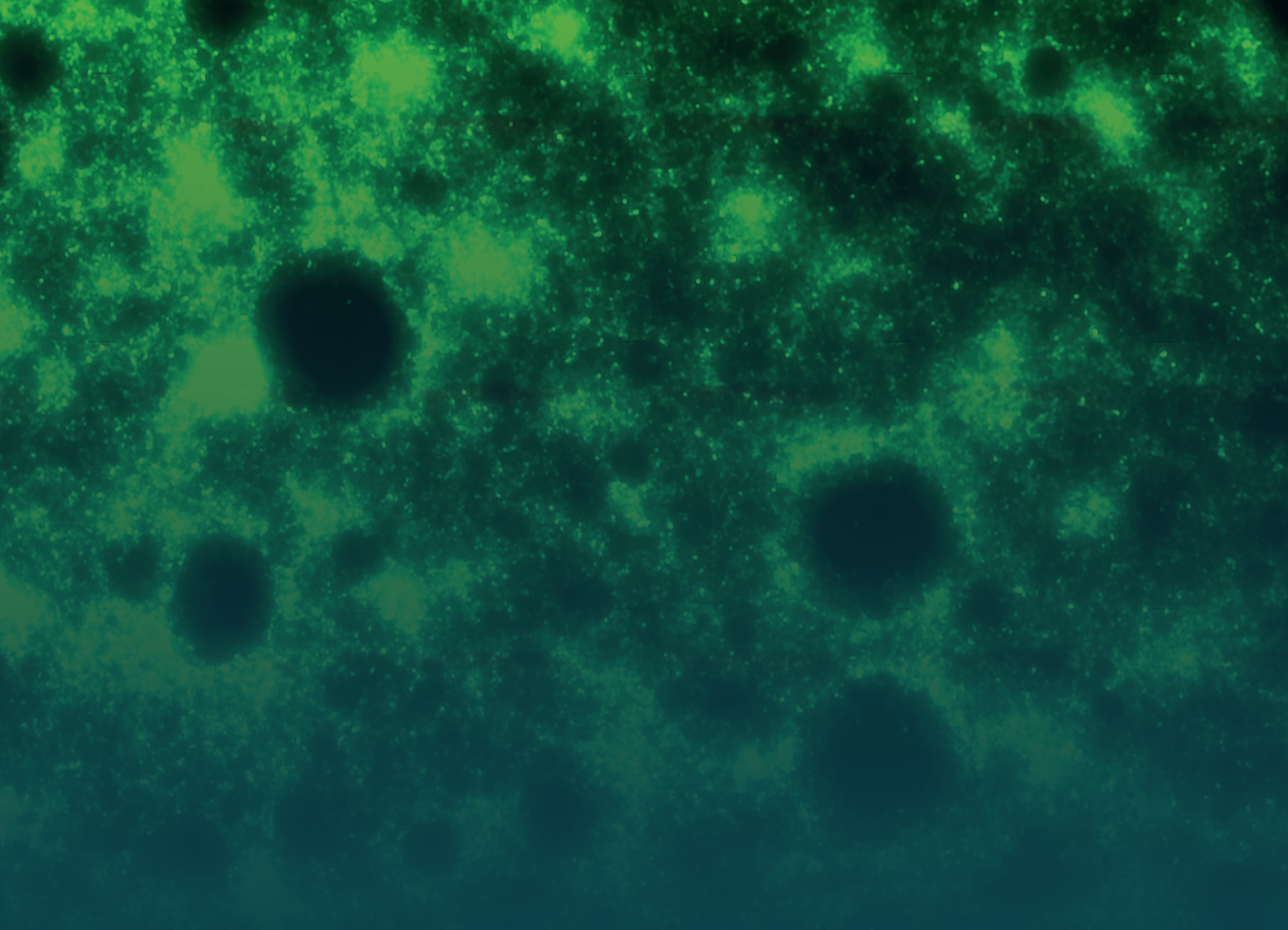
National Biofilms Innovation Centre

Annual Report 2023

HARNESSING THE UK'S ACADEMIC & INDUSTRIAL STRENGTH IN BIOFILMS





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NBIC ANNUAL REPORT 2023

Foreword

A FEW WORDS FROM OUR CEO

In December 2022, the National Biofilms Innovation Centre (NBIC) received additional funding from the Biotechnology and Biological Sciences Research Council (BBSRC) and Innovate UK to continue our important work. NBIC remains focused on supporting and connecting the industrial and academic biofilm community across the UK and with our international partners. We judge ourselves by our ability to harness and translate the capability, knowledge and technology in the prevention, detection, management and engineering of biofilms across the UK.

In last year's report I stated that, "we believe we are having significant impact across all these dimensions". This year I can report the extent of this impact. NBIC's total economic impact has been calculated as part of an external economic impact assessment to be £204m over the first 4 years of our operations. NBIC's intent remains to behave in a national, inclusive and transparent way to benefit our community. This year we will be launching a membership scheme for industry partners and we will bring in additional academic partners that share our desire to collaborate and connect with over 260 companies, which we continue to engage with across a range of sectors.

Over the next year we will deliver some of our ambitious plans in our three key pillars:

RESEARCH

Our funding has allowed us to continue to support our cohort of Interdisciplinary Research Fellows (IRFs) across our four core universities. They are all actively engaged in a mixture of underpinning research and projects with industry partners.

INNOVATION

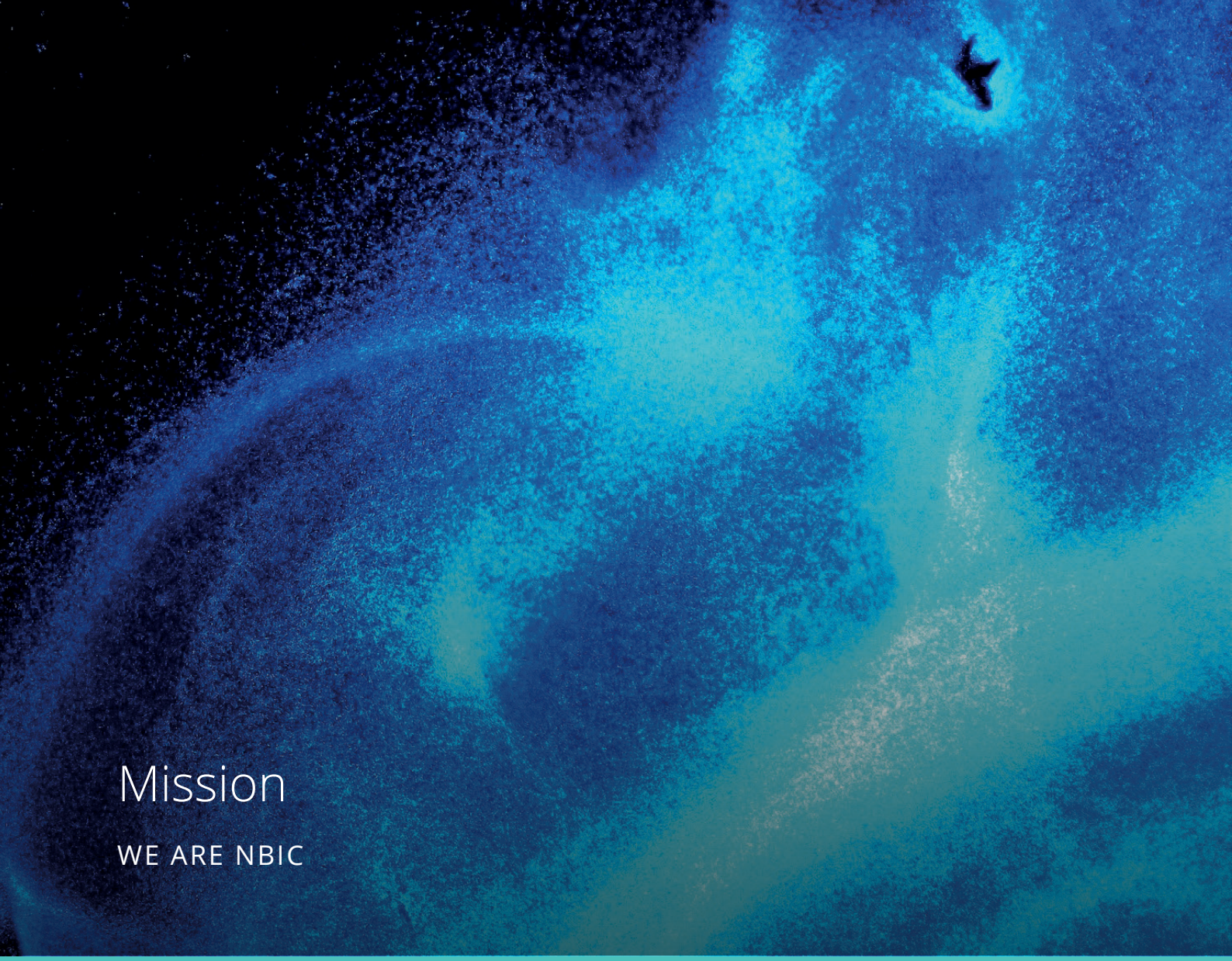
We will launch our first Proof of Concept/translational funding call and will continue to provide a unique forum for accelerating academic-industry partnerships to allow biofilm research approaches to be translated into innovation across multiple sectors. We are working with regulatory bodies to enable the development of standards that enable claims for biofilm-focused products.

TRAINING

We continue to build our cohort of PhD students across our four core universities for whom we are running a core Doctoral Training Centre in Biofilms Innovation, Technology and Engineering (BITE). In October 2021, BBSRC awarded NBIC's Industrial Advisory Board an annual allocation of funds from their Collaborative Training Partnerships (CTP) scheme to support interdisciplinary PhD studentships. The CTP scheme is a doctoral training programme directed at industrial research challenges and delivered by consortia led by businesses in collaboration with research organisations. Our call for project applications is currently open, so if you are interested, please visit our website to find out more.

It is very clear that everyone involved in biofilms across the UK remains jointly committed to our vision of delivering both breakthrough science and technologies to control and exploit biofilms, and to inspire the next generation of research leaders and entrepreneurs.

- PROFESSOR JO SLATER-JEFFERIES, NBIC CEO, AUGUST 2023



Mission

WE ARE NBIC

NBIC exists to create a fusion of world-class interdisciplinary research and industry partnerships to deliver breakthrough science and technologies to control and exploit biofilms.

Biofilms are central to our most important global challenges – from antimicrobial resistance and food safety to water security – and exert significant economic, social and environmental Impacts. NBIC was launched in 2017 to address these challenges and bring together the best of UK research and businesses to drive the translation of biofilm research into innovative solutions.

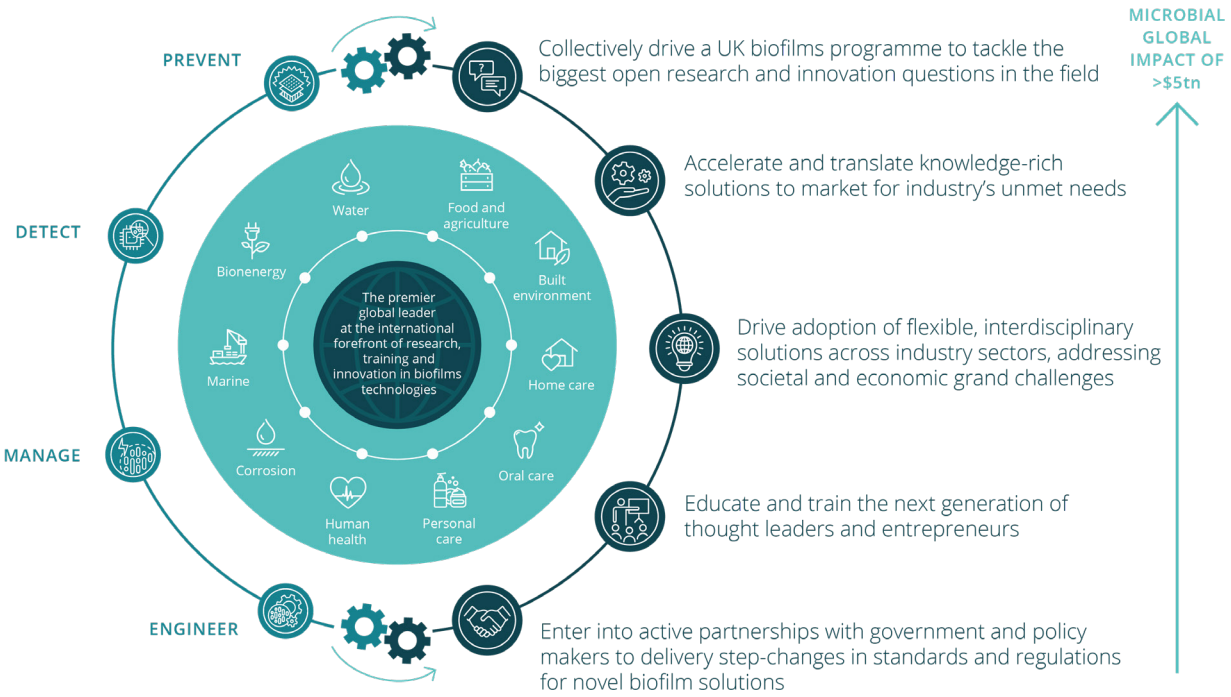
NBIC's vision is to create a truly pioneering and national centre, by bringing together the original four lead universities (Edinburgh, Liverpool, Nottingham and Southampton) and a partnership that has now expanded to include 59 research institutions, support from a growing base of more than 260 companies, and an inclusive strategy to new companies and research institutions.

In December 2022, BBSRC and Innovate UK invested £7.5m to support the Phase 2 rollout of the centre, which will support the continued expansion of world-class research and innovation.

In Phase 2, NBIC will build on its collective strengths as the UK's national centre to drive and expand its global leadership at the international forefront of research, training and innovation in biofilm technologies, addressing the grand challenges important to the UK's future prosperity.

Values

Microbial biofilms have a global impact across multiple industrial sectors, valued in excess of $5tn per annum. NBIC will capitalise on its role as the UK's national centre and deploy its interdisciplinary research power, critical mass, connected infrastructure and energised innovation ecosystem to deliver future ambitions.

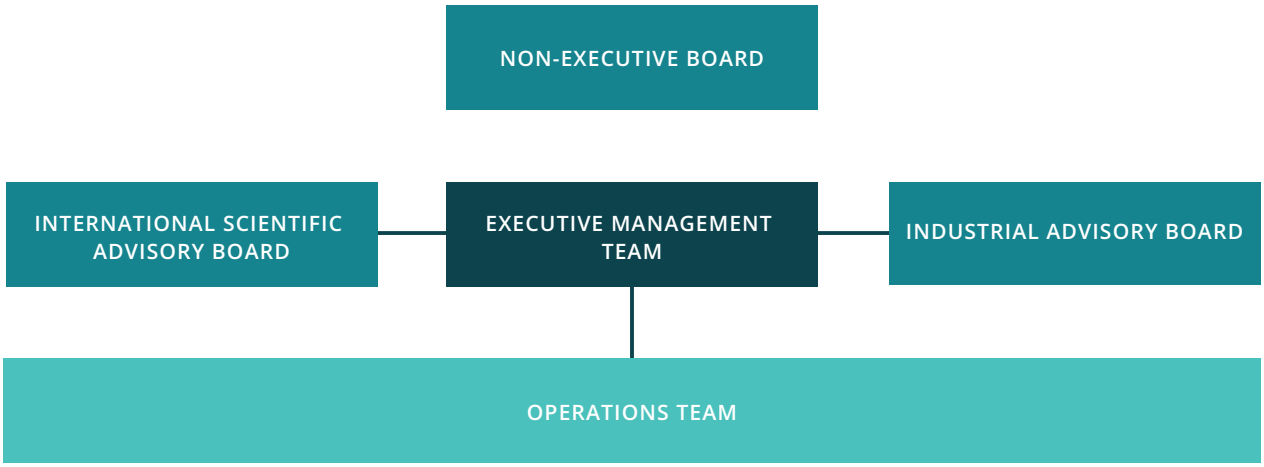


- NBIC will collectively drive a UK Biofilms Programme to tackle the biggest open research and innovation questions in the field and deliver global leadership and breakthrough science and innovation to Prevent, Detect, Manage and Engineer (PDME) biofilms.
- NBIC will enter into active partnerships with government and policy makers to deliver step-changes in standards and regulations for novel biofilm solutions.
- NBIC will assume global leadership via enhanced interactions with established global centres, while nucleating new relationships and networks with countries with rapidly expanding economic and healthcare challenges.
- NBIC will educate and train the next generation of leaders and entrepreneurs by delivering a co-created programme of training that addresses key skills gaps identified by our industrial and academic communities.
- NBIC will accelerate and translate knowledge-rich solutions to industry and the market via academic-industry collaborations, driving innovation and growth in multiple industrial sectors, nucleating new industries and spin-outs, and contributing to the Place agenda via close engagement with regional partners.
- NBIC's delivery and ambitions will remain agile, informed by active consultation across academia, industry and end users, alongside evolving national and global priorities and challenges.

Governance Structure

GOVERNANCE AND ADVISORY BOARDS

Our advisory boards aid NBIC in setting the strategic direction of research, innovation, training and outreach activities. Our Non-Executive Board regularly review NBIC's progress against our strategic plan.



EXTERNAL GOVERNANCE AND ADVISORY BOARDS

Non-Executive Board

NBIC's Non-Executive Board (NEB) is built from external members and includes representatives from NBIC's International Scientific Advisory Board (ISAB), Industrial Advisory Board (IAB) and funders. Their role is to guide the strategic direction and development of NBIC as well as having oversight of the operation and management of NBIC and the implementation of the Consortium Agreement.

ANDRE BURGESS
Strategic Partnerships, Resilience and Security Partnerships Directorate, National Physical Laboratory

GORDON FORD
Innovation Lead – Biomedical Enabling Technologies, Health & Life Sciences, Innovate UK

HILARY LAPPIN-SCOTT
Honorary Distinguished Professor, Cardiff University

FIONA LETTICE
Pro-Vice-Chancellor (Research & Innovation), University of East Anglia

KATH MACKAY
Director of Life Sciences, Bruntwood SciTech

SARAH NEELY
Senior Portfolio Manager (Health), Business Interaction Unit, Biotechnology and Biological Sciences Research Council

NEIL PARRY (CHAIR FROM JULY 2023)
R&D Programme Director, Biotechnology & Biosourcing, Unilever

MARK SUTTON
Scientific Leader, UKHSA

CERI WILLIAMS (CHAIR UNTIL JUNE 2023)
R&D Programme Director, Biotechnology & Biosourcing, Unilever

Industrial Advisory Board

NBIC's Industrial Advisory Board (IAB) includes business leaders from multinational companies and SMEs, brought to the Board on the basis of their experience and knowledge of the biofilms industry across the identified strategic sectors. They advise the Executive Management Team (EMT) on the development of NBIC, the industrial engagement strategy, funding calls and the commercial exploitation of the results of the research conducted through NBIC.

IAN ARCHER
Technical Director, IBioIC

DAVID BRADSHAW
Principal Innovation Scientist - Oral Care, GlaxoSmithKline (GSK)

KEN JOHNSTON
Consultant, Chilled Food Association

AMANDA LAKE (INCOMING)
Head of Carbon and Circular Economy, Jacobs Water Europe

NEIL PARRY (CHAIR UNTIL JULY 2023)
R&D Programme Director, Biotechnology & Biosourcing, Unilever

STEVEN PERCIVAL
Chief Executive Officer, 5D Health Protection Group Ltd

KIRSTY SALMON (CHAIR FROM AUGUST 2023)
VP Advanced Bio & Physical Sciences for Low Carbon Energy, BP Plc

STEWART MCKINLAY (OUTGOING)
Director of Research and Technology, Smith+Nephew

SU VARMA (INCOMING)
Academic Director, R&D Incubator, NSG Pilkington

CLAIRE HODGE (INCOMING)
Head of Crops, Agri-EPI Centre

International Scientific Advisory Board

NBIC's International Scientific Advisory Board (ISAB) brings together scientific leaders from international institutions to evaluate and challenge the scientific strategy of NBIC and its delivery and implementation in the context of the international development of the field. They advise the Executive Management Team (EMT) on the opportunities for exploitation of the scientific profile and advances made by the centre.

TOM COENYE
Professor, Laboratory of Pharmaceutical Microbiology, Ghent University, Belgium

LARS DIETRICH
Associate Professor, Columbia University, USA

HILARY LAPPIN-SCOTT (CHAIR)
Honorary Distinguished Professor, Cardiff University, UK

IÑIGO LASA
Professor of Microbiology, Navarrabiomed, Universidad Publica de Navarra, Spain

RIKKE LOUISE MEYER
Associate Professor, Interdisciplinary Nanoscience Center, Aarhus University, Denmark

AGNETA RICHTER-DAHLFORS
Professor in Cellular Microbiology, Karolinska Institutet. Professor in Chemistry and Biotechnology, KTH Royal Institute of Technology. Director of AIMES - Center for the Advancement of Integrated Medical and Engineering Sciences, KI & KTH, Sweden

MARK VAN LOOSDRECHT
Chair Professor in Environmental Biotechnology, Delft University of Technology, Netherlands

NBIC Executive Management Team

The Executive Management Team (EMT) have overall executive responsibility. In consultation with the International Scientific Advisory Board (ISAB) and the Industrial Advisory Board (IAB), the EMT develop NBIC's strategy and delivery plan.

Professor Miguel Cámara, NBIC Nottingham Co-Director

Miguel Cámara is a Professor of Molecular Microbiology in the School of Life Sciences at the University of Nottingham. He sits on the Cystic Fibrosis Trust Research Grants Review Committee and the Cystic Fibrosis Syndicate Steering Committee. He has also coordinated several international antimicrobial drug discovery programs. The core of his work has focused on the discovery of novel antimicrobial targets, studying quorum sensing (QS)-mediated signalling mechanisms and their control of virulence and biofilm formation and the identification of new biomarkers of infection. In collaboration with other researchers and industrial partners he is working on new drug delivery systems which can increase the penetration of compounds into biofilms and their uptake by bacteria.

Professor Cait MacPhee, NBIC Edinburgh Co-Director

Cait MacPhee is a Professor of Biological Physics at the University of Edinburgh. Her expertise is in the use of experimental and computational methods to understand mechanisms of self-assembly of peptides and proteins, and to interrogate microbial biofilm structure and function. She is able to advise on protein aggregation to form gels and particulate aggregates, the self-assembly of polypeptides and proteins at interfaces, analytical methods to assess the degree of polypeptide aggregation in formulations, methods to prevent or promote polypeptide aggregation, and methods to modulate the physical properties of formulations. She has prior experience of working with food-related products and pharmaceutical formulations.

Professor Rasmita Raval, NBIC Liverpool Co-Director

Rasmita Raval is a Professor in the Department of Chemistry, the Director of the Surface Science Research Centre and the Open Innovation Hub for Antimicrobial Surfaces at the University of Liverpool. Her research includes rational design of functional surfaces and bio-interfaces. There is strong emphasis on multi and inter-disciplinarity and her research group's expertise spans surface science, smart materials design, nanoscience, advanced analytical tools, metrology, imaging (from single atoms to cells), allied with microbiological and 'omic approaches. This experimental effort is combined with modelling to yield detailed insights into molecular and biological responses and behaviour at surfaces and to establish structure-property relationships.

Professor Jeremy Webb, NBIC Southampton Co-Director

Jeremy Webb is a Professor of Microbiology at the University of Southampton. His work focuses on the adaptive biology, antimicrobial resistance, evolution, and molecular genetics of biofilms and polymicrobial communities. His work includes investigation of the regulation and control of biofilm dispersal, which are now being exploited for therapeutic applications in cystic fibrosis, including the first human clinical trial for a biofilm-targeted therapeutic. Current research also seeks to identify genes that undergo adaptive evolution during bacterial biofilm development.

Professor Jo Slater-Jefferies, NBIC CEO

Jo Slater-Jefferies joined NBIC in April 2018 and became the CEO in October 2022. Jo has been a Director and Trustee of the Asthma, Allergy and Inflammation Research (AAIR) charity since 2011. She started her scientific career as a Senior Scientist and Quality Manager at Sciona Ltd., a spin-out company combining lifestyle data and genetic analysis. Between 2011 and 2018 she held the position of General Manager for EpiGen, a global research consortium. Jo holds a BSc Honours in molecular biology and an industrial sponsored PhD from the University of Portsmouth. In 2014, Jo received an MBA, and in 2017 became a Chartered Manager at the Chartered Management Institute. In 2022, Jo was recognised for her contribution to Enterprise and Knowledge Exchange by the University of Southampton and appointed as Professorial Fellow (Enterprise).

Operational Team

EXECUTING NBIC'S STRATEGY

William Green, Innovation and Partnership Manager

William joined NBIC in November 2018. William started his scientific career at Fugro EMU Ltd as a Project Manager in the microbiology laboratory delivering water and environmental testing to a range of clients, including the NHS and Carnival UK. He then moved to the University of Portsmouth where he built and maintained the commercial offering of the University's research equipment, including bimolecular services, geotechnical services, marine science, materials testing, motion capture, human performance, canine facial expression recognition, imaging and 3D printing. William has a degree in Microbiology and Biotechnology from the University of Portsmouth. William is working to identify and deliver investment to NBIC's core partners through research and commercialisation of partners IP and will develop and manage external relationships with strategic academic and commercial partners.

Natalia Romo Catalan, Operational Manager

Natalia joined NBIC in 2021. She started as a Research Associate and became a Research Fellow in 2022, where she focused on quorum sensing and regulation of the *pqs* system in *P. aeruginosa*. Among her roles, Natalia implemented and oversaw data management for NBIC Nottingham. In 2023, Natalia moved to a new position as Operations Manager where she supports NBIC's CEO and Operational Team in the effective operational management of NBIC, which includes ensuring outgoing funding calls are effectively managed, delivering the NBIC membership scheme and UK Biofilms Foundation and ensuring that NBIC's Data Management and IP Management plan are implemented effectively. Natalia holds a PhD in Microbiology from the University of Nottingham and a degree in Pharmacy from the University of Valparaiso, Chile.

Dr Jean-Christophe Denis, Public Engagement & Outreach Officer

After an academic research career (Engineering studies at Supelec in France, followed by a PhD and Postdoc in Chemical Physics at Heriot-Watt University in Edinburgh), JC followed his passion and moved to the position of Outreach and Public Engagement Officer in 2017. JC first got involved in outreach in 2006 when he co-organised science events for school students from deprived areas around Paris. With NBIC, JC plans to develop biofilm-related engagement activities, focusing on educators, families and people with little interest in science. JC supports the NBIC community with the development and delivery of public engagement and outreach activities to ensure that the NBIC commitment to this area is delivered.

Becky Levy, Operational Support

Becky joined NBIC in 2023 as Operational Support in Southampton. Previous to this, she was working as an Operational Marketing Lead at a financial platform and as a Customer Account and Communications Lead for an independent brand. Becky's role is to provide support to the Chief Executive Officer and Co-Director of Southampton as well as providing administrative support to the wider NBIC team.

Susanna Richmond, Impact Manager

Susanna is based at the School of Physics and Astronomy at the University of Edinburgh where she is the School's Impact Research Officer alongside her NBIC role. Previously, she worked within the editorial team at the open-access science publication, eLife, and holds a degree in Physics from the University of Edinburgh. Susanna supports the Executive Management and Operational Teams in the collection, analysis, and reporting of metrics and evidence that demonstrate the impact of NBIC's activities.

Ines Foidl, Edinburgh Coordinator

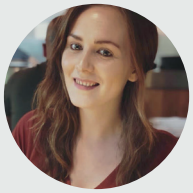
Ines is based at the School of Physics and Astronomy at the University of Edinburgh, where she is the Administrator for NBIC and the Higgs Centre for Theoretical Physics. Ines has held positions at International Organisations and in the Higher Education sector, where she worked on organisational, structural and project administration matters. She holds an MA (Hons) in History and International Relations from the University of Dundee and a Master of Advanced International Studies from the University of Vienna. Ines works with academics to provide administrative and strategic support to the NBIC Edinburgh team and works on matters relating to public and policy engagement for NBIC at large.

Dr Jaspreet Mand, CTP.BITE Programme Manager

Jaspreet joined NBIC in December 2022. Jaspreet started her scientific career in R&D with ExxonMobil, where she researched biofilms associated with the energy industry. She has experience using advanced 'omics technologies to develop novel detection and monitoring methods for microbially influenced corrosion. Jaspreet holds a BSc in Cellular Molecular & Microbial Biology and a PhD in Environmental Microbiology from the University of Calgary, Canada. Jaspreet is involved in all aspects of the management and administration of the NBIC Collaborative Training Partnership (CTP) and NBIC Doctoral Training Centre in Biofilms Innovation, Technology and Engineering (BITE) across all industrial and academic partners.

Bismillah Kosser, Research Development Officer

Bismillah provides assistance to the NBIC Nottingham Co-Director, including travel and diary management, and supports the organisation, management and logistics of recruitment activities, as well as meetings, symposia, courses, outreach events and other training activities for NBIC staff.



Natasha Nater, Communications Manager

Natasha started her career in science focused communications at the University of Southampton's on campus start-up platform and business accelerator, Future Worlds. She led on the development and implementation of a medical-focused communications strategy and produced enterprise events and video content to support researchers and aspiring entrepreneurs to develop high impact start-ups and spinouts. She specialises in digital communications, social media strategy and brand awareness. Natasha holds a CIM Diploma in Professional Digital Marketing and a BA in Television Production from Bournemouth University. Natasha provides specialist knowledge on all communications relating to NBIC and manages the Marketing and Communications strategy to promote the organisation's successes and the work of NBIC researchers.

Dr Paulina Rakowska, Biofilms Standards & Regulatory Programme Manager

Paulina joined NBIC in September 2020. She built her scientific career at the UK's National Physical Laboratory (NPL), where she worked for 14 years leading metrology projects, firstly in the Biometrology Group, then in the National Centre of Excellence in Mass Spectrometry Imaging (NiCE-MSI). She has a vast experience in analytical R&D and a portfolio of successful grant proposals and delivery of projects of different sizes, timescales and complexities, at the interface of physics, biology, chemistry and nanotechnology. Paulina holds a MSc in Biotechnological Processes from the Wroclaw University of Technology in Poland and a PhD in Chemical Biology from the University College London. Paulina develops and manages external relationships with government and policy makers to deliver step changes in biofilm standards and regulations, and works with NBIC Co-Directors to identify and deliver investment to NBIC's core partners that enable the development of biofilm standards and biofilm biobanks.

Building an International Community of Biofilm Researchers

- 63 UK research institutions
- Integrated and interdisciplinary consortium
- A network of over 260 companies and organisations with sectoral needs and opportunities
- Memorandum of Understanding (MOU)'s and links with leading international centres

Our Achievements

SINCE 2017

START OF THE JOURNEY

FEBRUARY 2018, KNOWLEDGE TRANSFER NETWORK BIOFILM WORKSHOP
NBIC attended and launched at a Knowledge Transfer Network (KTN) workshop on identifying and prioritising industrial challenges and solutions in controlling and exploiting biofilms.

JUNE 2018, FIRST PROOF OF CONCEPT CALL LAUNCHED
Call for projects tackling biofilms launched in the UK - open to all members of the NBIC consortium and industry collaborators.

SEPTEMBER 2018, FIRST NBIC WORKSHOP & THEORY OF CHANGE MODEL ESTABLISHED
First cross-sectorial workshop on one of NBIC's 4 key strategic themes, Detect, was held in Birmingham, with 70 delegates from academia and industry coming together to discuss unmet needs.
Our aims for the next 5 years were established in a comprehensive Theory of Change model, with the ultimate long-term goal of growing the UK economy.

NOVEMBER 2018, NBIC WON BBSRC FTMA (FLEXIBLE TALENT MOBILITY ACCOUNT) AWARD
Won funding to facilitate PhD and research fellow mobility between academia and industry.

MARCH 2019, MEMORANDUM OF UNDERSTANDING SIGNED WITH SCELSE IN SINGAPORE
We signed a Memorandum of Understanding (MOU) with the Singapore Centre for Environmental Life Sciences Engineering (SCELSE) to address global biofilm challenges through collaborative projects and student and staff exchanges. We also formed a close partnership with the Singapore National Biofilms Consortium (SNBC), led by SCELSE, to further commercial opportunities and drive technological advancements.

MAY 2019, FIRST NBIC ANNUAL RESEARCH SUMMIT & INTERNATIONAL SCIENTIFIC ADVISORY BOARD (ISAB) ENDORSEMENT
The first NBIC Annual Research Summit was held at the Royal Society, where our researchers showcased their work and we received endorsement from ISAB regarding our research strategy.

JULY 2019, SECOND PROOF OF CONCEPT CALL PROJECTS AWARDED
A further 26 projects awarded funding, bringing the total number of projects to 51 and a total investment of £2.79m from NBIC, with an overall project value of £4.05m.

SEPTEMBER 2019, SUCCESSFUL 2 YEAR FUNDING REVIEW
As part of the condition of the NBIC IKC award. An external panel reviewed the progress of NBIC against their vision, mission and key performance indicators (KPIs). The panel deemed that NBIC was making good progress, the highest outcome that could be expected.

2017

DECEMBER 2017, NATIONAL BIOFILMS INNOVATION CENTRE ESTABLISHED
£26m investment from BBSRC, Innovate UK and the Hartree Centre with additional funding from industry and the support of 4 core partner universities: Edinburgh, Liverpool, Nottingham and Southampton.

2018

MAY 2018, PARTNER MEETING & 1ST WAVE ACCESSION
Partner meeting in York brought together representatives from research institutions interested in joining NBIC.
12 new research institutions join the NBIC consortium, bringing us to a total of 16.

AUGUST 2018, 2ND WAVE ACCESSION
Welcomed 15 new research institutions to the NBIC consortium, taking our total to 31 institutions.

OCTOBER 2018, FUNDING OF 25 NEW PROJECTS & GOING INTERNATIONAL
NBIC invested £1.4m, averaging £50k per project, to 25 new projects from the first POC call. The total project value, with company investment, amounting to approximately £2.1m.
NBIC launched at the American Society for Microbiology in Washington, and visited the Center for Biofilm Engineering (CBE) at Montana State University, where a Memorandum of Understanding (MOU) was signed, declaring to work together, partake in student exchanges and knowledge transfer.

DECEMBER 2018, >60 BUSINESSES AND INDUSTRY COLLABORATORS TO DATE
From large multinationals to SMEs, NBIC continues to grow in its mission to control and exploit biofilms by bringing research and industry together.

2019

APRIL 2019, BIOFILM ENGINEERING WORKSHOP HELD, SECOND PROOF OF CONCEPT CALL LAUNCHED & RECEIVED INTERNATIONAL WORKSHOP AWARD
Second cross-sectorial workshop on one of NBIC's 4 key strategic themes, Engineer, was held in Edinburgh, bringing together over 85 delegates from academia and industry to discuss and identify unmet needs and facilitate collaborations.
Our second Proof of Concept call was launched – open to all members of the NBIC consortium and industry collaborators.
We were also awarded £10k by BBSRC to host an international symposium on 'Microbes and Metals'.

JUNE 2019, 3RD WAVE ACCESSION
14 new research instutions joined the NBIC consortium, bringing us to a total of 45.

SEPTEMBER 2019, NBIC ATTEND EUROBIOFILMS
NBIC attended the Eurobiofilms meeting in Glasgow. This was the first meeting we had attended as a full NBIC team with our new brand. It was a great chance for us to meet our partners and make new contacts. We also had the honour to present at the final session.

2020

DECEMBER 2020, SKIN MICROBIOME AND BIOFILMS WEBINAR

Together with Cosmetics Cluster UK (CCUK) NBIC held a joint webinar, 'The science behind the skin microbiome and biofilms – evidence and claims'. Skin microbiome claims are becoming a trend in many categories yet the science is in its relative infancy. This webinar included presentations and discussions covering the market, research and innovation, and addressed questions like, "can pro/prebiotics be used in cosmetics?" and "how can claims be credible and relevant to the consumers?".

OCTOBER 2020, MARINE BIOFOULING WEBINARS

In conjunction with the Plymouth Marine Laboratory and the Singapore National Biofilm Consortium NBIC held a series of webinars on marine biofouling. This webinar series was designed to inform cross sector participants of the current challenges in producing efficacious antifouling coatings under the current regulatory framework, but also to investigate the novel antifouling technology development opportunities this legislative pressure is stimulating.

JUNE 2020, FIRST ONLINE ENTREPRENEURIAL TRAINING COHORT

Run in collaboration with Alderley Park, NBIC members participated in a 2 ½ day pre-accelerator programme to explore how to take their idea or early business forward with the chance to be funded by NBIC in a further mentored 8-week full accelerator programme.

MAY 2020, THIRD PROOF OF CONCEPT CALL PROJECTS AWARDED

A further 14 projects awarded funding, bringing the total number of projects to 65 and a total investment £3.6m from NBIC and £5.4m total value when we also consider funds from companies either in cash or in kind. These awarded projects have involved 28 research institutions, 52 companies and of these companies, 33 are SMEs.

FEBRUARY 2020, FLEXIBLE TALENT MOBILITY AWARD

NBIC awarded a second round of funding from BBSRC to support our current Flexible Talent Mobility Award (FTMA) Account, with a call opening in September 2020 with the aim to fund innovation placements and fellowships, perspectives and knowledge, skills and expertise between the academic and industrial sectors.

FEBRUARY 2020, 4TH WAVE ACCESSION

7 new research institutions joined the NBIC consortium, bringing us to a total of 52.

NOVEMBER 2019, MICROBE-METAL INTERACTIONS WORKSHOP

Our workshop on microbe-metal interactions was held in London. This workshop brought together key complementary academic expertise and thought leadership from industry in biofilms, contamination of metal surfaces and biocorrosion processes across the life and physical sciences and engineering domains within NBIC, CBE and internationally, in order to identify the key knowledge gaps and research challenges for future projects and research collaboration.

DECEMBER 2020, NBIC LAUNCH THEIR RESEARCHFISH PLATFORM

The Researchfish plartform allows NBIC grant holders and funded researchers, to upload outcome data about research to multiple funders easily and quickly, in order to capture the outcomes of NBIC funded research.

DECEMBER 2020, FOURTH PROOF OF CONCEPT CALL LAUNCHED

Fourth call for projects tackling and exploiting biofilms launched in the UK - open to all members of the NBIC consortium and industry collaborators.

AUGUST 2020, LAUNCH OF #BIOFILMAWARE CAMPAIGN

NBIC announced the launch of their biofilm awareness campaign. Through a blend of content, events and outreach activities #BiofilmAware works to raise awareness of NBIC and its research, and the many societal and economic impacts of biofilms.

JUNE 2020, LAUNCH OF BITE DOCTORAL COLLEGE TRAINING

The NBIC Doctoral Training Centre in Biofilms Innovation, Technology and Engineering (BITE) is launched. A world-class integrated pipeline of interdisciplinary training, it is the UK's first graduate training centre to address the skills and knowledge gap in the biofilm field.

MARCH 2020, INTERNATIONAL PARTNERING AWARD

NBIC received a funding award 'Singapore: Building a globally leading partnership between the National Biofilms Innovation Centre and SCELSE', which enabled NBIC to facilitate PhD and research fellow mobility between the UK and Singapore.

FEBRUARY 2020, FORMATION OF INTERNATIONAL STANDARDS TASK GROUP

To address the rise in prevalence and popularity of biofilm and microbiome technologies an international task group was formed. The first meeting of the task group was held in Virginia (USA), with delegates from SCELSE, the Center for Biofilm Engineering (CBE; USA) NBIC, and the Singapore National Biofilm Consortium (SNBC), along with representatives from regulatory bodies and agencies from the USA and the European Union.

FEBRUARY 2020, BIOFILM MANAGEMENT WORKSHOP

Third cross-sectorial workshop on one of NBIC's 4 key strategic themes, Manage, was held in Nottingham. This workshop was aimed at exploring unmet industrial needs in the field of biofilm management. NBIC partner organisations shared their unmet needs and the 65 attendees (34 from industry) worked in syndicates to discuss the key challenges and ways to overcome them.

NOVEMBER 2019, SOFTWARE SUSTAINABILITY WORKSHOP

The Software Sustainability Workshop brought together 20 attendees from seven UK universities, plus Unilever, in Birmingham. We ran this event alongside the Software Sustainability Institute in a bid to raise awareness of the need for sustainability in software, particularly when it comes to the potential risks to software reproducibility.

2021

DECEMBER 2020, SOFTWARE SUSTAINABILITY INSTITUTE WORKSHOPS

The Software Carpentry Workshop focused on fundamental data skills needed to conduct research, included writing, managing and automation of code for conducting more robust and reproducible research. The Data Carpentry Workshop was aimed at researchers in the NBIC community who have little to no prior computational experience, and explored best practices for data management and organisation using spreadsheets, data cleaning using OpenRefine, and data analysis skills in R.

FEBRUARY 2021, NBIC CONTRIBUTE TO THE KTN MICROBIOME STRATEGIC ROADMAP

As a member of the KTN Microbiome Innovation Network, NBIC are proud to have contributed to the KTN Microbiome Strategic Roadmap in the personal care and hygiene sector.

FEBRUARY 2021, MICROBES AND BIOFILMS IN THE FOOD INDUSTRY

NBIC's joint webinar with the Society for Applied Microbiology (SfAM) was designed for anyone working in either the production of food or researching/controlling the role microbes and biofilms play in the whole food chain.

MARCH 2021, LAUNCH OF THE PRIORITY QUESTIONS EXERCISE FOR MICROBIAL BIOFILMS

Together with the Center for Biofilm Engineering (CBE), Singapore Centre for Environmental Life Sciences Engineering (SCELSE), COST AMiCI Consortium and the ESCMID Study Group for Biofilms (ESGB) we called on the international biofilm community to help us identify priority questions that, if answered, will make a considerable impact on the fundamentals of the field of microbial biofilms, to innovation in approaches to prevent, detect, manage and engineer biofilms, or which would be expected to have an impact in influencing policy makers and funders.

MAY 2021, BIOAEROSOL CHARACTERISATION, THE AIR MICROBIOME AND COVID-19 TRANSMISSION WEBINAR

Our joint webinar with Singapore Centre for Environmental Life Sciences Engineering (SCELSE) and Singapore National Biofilm Consortium (SNBC) was supported by the Singapore Manufacturing Federation. The webinar was aimed at researchers, companies and regulators involved in either studying or directly influencing and intervening in the air microbiome in different contexts and climatic conditions.

JUNE 2021, NBIC FOCUS GROUP WITH CELLEXUS AND CELLEVATE

This focus group with the companies Cellexus, and Cellevate was aimed at anyone working in the field of biofilm culturing, interested in developing improved model systems.

AUGUST 2021, NBIC LAUNCH FIRST #BIOFILMWEEK

The first ever awareness week dedicated to celebrating all things biofilm took place between 16-22 August 2021. #BiofilmWeek promotes the economic and physical impact that biofilms have on our world, and highlights research taking place to prevent, detect, manage and engineer biofilms.

JANUARY 2021, NBIC LAUNCH #BIOFILMAWARE PHOTO COMPETITIONS

NBIC launched two national biofilm photo competitions as part of their #BiofilmAware campaign - 'Biofilms in Real Life' and 'Biofilms in the Lab'.

FEBRUARY 2021, NBIC AND INDIA BIOFILMS SOCIETY SYMPOSIUMS

NBIC hosted three open joint online biofilms symposiums between UK biofilm researchers from the NBIC academic community, and from the newly formed India Biofilms Society.

MARCH 2021, 5TH WAVE ACCESSION

11 new research institutions joined the NBIC consortium, bringing us to a total of 63.

MARCH 2021, STUDYING AND CONTROLLING THE MICROBIOME OF THE AIR WEBINAR

Our joint webinar 'Studying and Controlling the Microbiome of the Air' with the Singapore Centre for Environmental Life Sciences Engineering (SCELSE) and Singapore National Biofilm Consortium (SNBC) was designed for anyone in industry and academia with an interest in transmission of bacteria and viruses in both outdoor and built environment and what the evidence is starting to tell us about this field and the future work that is needed.

MAY 2021, INNOVATION IN DEODORANTS WEBINAR

Our joint 'Innovation in Deodorants' webinar with Cosmetics Cluster UK (CCUK) looked at innovation trends and market opportunities in deodorants, translational research in skin microbiome/biofilms, *in vitro* alternatives to animal testing, new technology and small brand perspectives and promoting consumer health and sustainability.

JUNE 2021, FOURTH POC CALL AWARDED

A fourth portfolio of projects awarded in the UK between universities and industry partners with a focus on controlling and exploiting biofilms. This brings the NBIC portfolio of projects funded since it launched in December 2017 to 81 representing a programme value of £6.7m.

JULY 2021, PRIZES AWARDED TO WINNERS OF THE #BIOFILMAWARE PHOTO COMPETITIONS

Our two national NBIC photo competitions which formed part of our #BiofilmAware campaign ran from January through to 31 May 2021. 'Biofilms in Real Life' received 53 entries and 'Biofilms in the Lab' received 42. A diverse panel of 6 judges took into account creativity, originality, composition, imagination used, scientific value and the overall artistic impression and Amazon gift cards were awarded to first, second and third place in both competitions.

AUGUST 2021, TWO NBIC FUNDED PROJECTS WITH THE QUADRAM INSTITUTE LAUNCHED

The MicroBattle card game, to communicate the importance of bacterial diversity within biofilms, and the 'Biofilm Brainhub' website, built with the support of the wider research community, which aims to be the 'go-to-place' for anyone looking to learn about biofilms.

2022

MARCH 2022, BIOFILMS ICURE SPRINT CALL LAUNCHED
Funded by NBIC and delivered by SETsquared, the Biofilms ICURe Sprint is an accelerated version of the Innovation to Commercialisation of University Research (ICURe) programme, dedicated solely to research teams developing biofilm innovations. The programme supports teams led by early career university researchers to determine whether there is an international biofilms market for products or services that utilise their research, science, or technology.

FEBRUARY 2022, UK-INDIA-SINGAPORE BIOFILM SERIES, BIOFILMS AND ENGINEERED SYSTEMS WEBINAR
The second in our joint webinar series with the India Biofilms Society (IBS) and the Singapore Centre for Environmental Life Sciences Engineering (SCELSE), which aimed to foster interactions between biofilm researchers in the UK, India, and Singapore. This webinar focused on the theme, 'Biofilms and Engineered Systems'.

FEBRUARY 2022, GHANA PARTNERING GRANT AWARDED
NBIC was awarded BBSRC funding to run a workshop aimed at establishing a new partnership between NBIC and the West African Centre for Cell Biology of Infectious Pathogens (WACCBIP) in Ghana to address biofilm-related challenges.

DECEMBER 2021, MICROBIAL IMPACTS CONFERENCE
The 2021 Microbial Impacts Regional Networking Meeting in Southampton aimed to connect and accelerate new collaborations, catalyse exchange of ideas, and new collaborations addressing global challenges relevant to the field, and to build on research and innovation strengths in the Wessex and South Coast region.

NOVEMBER 2021, NBIC ALL PARTNER MEETING
This was an opportunity for the NBIC community to review progress, successes, and challenges since our formation in December 2017, and to discuss how the UK biofilm community can continue to leverage its strength. The NBIC community reviewed progress against the original NBIC goals and provided input to guide NBICs future direction and how we can best help grow further biofilm research, translation and education in the UK.

OCTOBER 2021, WOMENS HEALTH AND FEMININE CARE WEBINAR
The joint 'Women's Health and Feminine Care' webinar from NBIC and Cosmetics Cluster UK (CCUK) brought together both academic and industry expertise and took a broad approach to research and development in skin and vaginal health and through life stages with a particular focus on non-invasive sampling methods and pre-clinical models. This webinar looked at the latest research and innovation as well as market trends, consumer needs and new technology solutions in the popular subject of women's health.

OCTOBER 2021, NBIC COLLABORATIVE TRAINING PARTNERSHIP (CTP2) AWARDED
The BBSRC awarded NBIC's Industrial Advisory Board an annual allocation of funds from their Collaborative Training Partnerships (CTP) scheme to support interdisciplinary PhD studentships. The CTP scheme is a doctoral training programme directed at industrial research challenges and delivered by consortia led by businesses in collaboration with research organisations.

SEPTEMBER 2021, DRINKING WATER DISTRIBUTION SYSTEMS AND ALTERNATIVE WATER RESOURCES WEBINAR
Our joint webinar with Singapore Centre for Environmental Life Sciences Engineering (SCELSE), Singapore Membrane Consortium (SGMEM) and Singapore National Biofilm Consortium (SNBC), focused on biofilms in water distribution systems and membrane development for reverse osmosis (RO).

FEBRUARY 2022, UTILISING METAGENOMICS IN EARLY TO LATE-STAGE R&D WEBINAR
Our webinar with Jennifer Mackay and Dana Walsh of CosmosID was aimed primarily at PhD and postdoctoral researchers in our network and for those interested in learning more about metagenomics workflows, the challenges involved and the things that need to be controlled to provide a quality outcome.

FEBRUARY 2022, ARGENTINA PARTNERING GRANT AWARDED
This BBSRC grant supported a workshop titled 'Biofilms in Agriculture' which took place in October 2022. Co-organised by NBIC and the Argentinean Society for General Microbiology (SAMIGE), aimed to bring together key researchers and industry representatives from both countries to catalyse collaborations in the area of plant-microbial interactions and sustainable crop production.

JANUARY 2022, NBIC BIOFILM STANDARDS AND REGULATORY NEEDS: INDUSTRY FEEDBACK SESSION
NBIC held a consultation session with a group of representatives from industry, focused on the medical device and pharma sectors, to understand their most pressing needs in terms of biofilms standardisation. The discussion helped to define the subsequent, full day workshop in April 2022.

NOVEMBER 2021, NBIC BIOFILM PREVENTION WORKSHOP
This workshop provided a unique forum for accelerating academic-industry partnerships to allow prevention-based research approaches to be translated into innovation across multiple sectors. An initial plenary session was led by NBIC to summarise and discuss an outline scope of the needs, followed by cross industry-academic group sessions, and an opportunity for short pitches of ideas or problems.

OCTOBER 2021, THE WATER CYCLE, RESERVOIR AND STORMWATER MANAGEMENT WEBINAR
Our joint webinar with Singapore Centre for Environmental Life Sciences Engineering (SCELSE), Singapore Membrane Consortium (SGMEM) and Singapore National Biofilm Consortium (SNBC), focused on managing emerging pollutants, and other innovations in reservoir and stormwater management.

OCTOBER 2021, INNOVATION IN WASTEWATER TREATMENT WEBINAR
Our joint webinar with Singapore Centre for Environmental Life Sciences Engineering (SCELSE), Singapore Membrane Consortium (SGMEM) and Singapore National Biofilm Consortium (SNBC), focused on tackling industrial and greasy wastewater and using ecological theory to evaluate microbial process performance. Additionally, we considered innovations in wastewater treatment.

SEPTEMBER 2021, UK-INDIA-SINGAPORE BIOFILM SERIES, HEALTH/CLINICAL WEBINAR
The first in our joint webinar series with the India Biofilms Society (IBS) and the Singapore Centre for Environmental Life Sciences Engineering (SCELSE), aimed to foster interactions between biofilm researchers in the UK, India, and Singapore. The first webinar focused on the theme, 'Health/Clinical'.

MARCH 2022, BABY SKIN AND THE MICROBIOME WEBINAR
Our joint webinar with Cosmetics Cluster UK (CCUK) brought together academic and industry expertise to focus on personal care innovation in the area of infant and baby care with a focus on the skin microbiome. The webinar took a broader approach to encompass all possible R&D developments in gentle formulations and mildness testing, sustainable ingredient trends and baby skin-microbiome biology, and covered innovation, regulatory aspects, brand perspectives and consumer attitudes.

JUNE 2022, BIOFILMS AND BIOACTIVE FLUIDS WORKSHOP
The Biofilms and BioActive Fluids workshop in Liverpool was a joint venture between the UK BioActive Fluids Network and NBIC. The workshop sought to foster interactions between industry and academic researchers working on biofilms and on biologically active fluids.

JUNE 2022, CELL–CELL COMMUNICATION IN BACTERIA: FUNDAMENTAL AND APPLIED ASPECTS
The 2022 biennial bacterial Cell–Cell Communication meeting organised by the Microbiology Society was held at Robinson College in Cambridge. Helen Blackwell from University of Wisconsin–Madison gave an NBIC sponsored lecture titled 'Chemical approaches to intercept quorum sensing in bacteria' and members of the team held a stand at the meeting to highlight NBIC research and activities.

JULY 2022, GRANULAR ACTIVATED CARBON BIOFILMS FOR BIOMETHANATION FROM WASTEWATER WEBINAR
EBNet, in partnership with NBIC, hosted this webinar to support knowledge exchange amongst members, and provided the latest developments from top speakers at Cranfield Water Science Institute and Imperial College London.

OCTOBER 2022, FIRST NBIC COLLABORATIVE TRAINING PROGRAMME
NBIC welcomed the first cohort of PhD students for the Collaborative Training Programme from across the country. CTP students are collaborating with industry on a variety of interdisciplinary biofilm research projects.

OCTOBER 2022, NBIC IN PARLIAMENT
NBIC's CEO Jo Slater-Jefferies pitched to the (then)UK Commons Science and Technology Committee at the 'My Science Inquiry' event on the importance of biofilm standards and regulations.

OCTOBER 2022, LAUNCH OF NBIC ICURE PHASE 2
The second phase of NBIC's ICURe programme was launched. This programme delivered collaboration, licencing, and start-up training to 6 project teams.

NOVEMBER 2022, EDINBURGH BIOFILMS TOUR
As part of #BiofilmWeek 2022, researchers in the School of Physics & Astronomy at the University of Edinburgh launched a Biofilm Tour of Edinburgh, exploring where biofilms exist across some of the city's famous sights.

DECEMBER 2022, FIFTH ROUND OF FTMA FUNDING AWARDED
NBIC awarded a fifth round of funding from BBSRC to support our Flexible Talent Mobility Award (FTMA) Account. This funding supports secondments and other activities that contribute to the mobility and development of researchers and technical staff in both academia and industry.

APRIL 2022, BIOFILM REGULATIONS AND STANDARDS WORKSHOP
The Workshop on Biofilm Regulations and Standardisation in the Medical Device and Pharma sectors was organised in collaboration with the USA Center for Biofilm Engineering (CBE) and supported by a BBSRC Global Partnering Award. The meeting brought together over 40 representatives from industry, academia, metrology and standardisation and regulatory bodies to map the current landscape, needs, trends and expectations in biofilm standardisation within the UK and to establish industry and regulatory participation in a forward working group.

JUNE 2022, NBIC ANNUAL RESEARCH SUMMIT AND INTERNATIONAL SCIENTIFIC ADVISORY BOARD (ISAB) ENDORSEMENT
A two-day event bringing together researchers and operations staff from the four core NBIC research institutions, with our three governance boards, for the purpose of discussing our progress, future plans and the science being undertaken by those involved.

JULY 2022, NBIC COLLABORATIVE TRAINING PARTNERSHIP (CTP2) GRANTS AWARDED
NBIC awarded four studentships which started in October 2022.

AUGUST 2022, NBIC ATTENDED EUROBIOFIMS '22
NBIC attended the Eurobiofilms conference in Palma de Mallorca, providing sponsorship and contributing a number of scientific talks and poster presentations, which covered diverse fields concerned with biofilms research.

OCTOBER 2022, NBIC ATTENDED NEW SCIENTIST LIVE
NBIC exhibited at New Scientist Live 2022, engaging with the thousands of festival attendees on how biofilms are part of our everyday lives. Visitors used water guns and giant mouth models to explore how plaque (a biofilm) makes it more difficult to clean your teeth, and there was also a water purifying activity to illustrate how biofilms are essential to clean water in sewage treatment plants.

OCTOBER 2022, BIOFILMS IN AGRICULTURE PARTNERING WORKSHOP IN ARGENTINA
The Biofilms in Agriculture workshop brought together researchers and industry representatives from NBIC and Argentina, to address knowledge gaps and improve agricultural productivity in both countries by reducing the use of chemical treatments and their environmental impact.

NOVEMBER 2022, WASTEWATER TREATMENT EVENT
This Edinburgh Complex Fluids Partnership (ECFP) event, run in collaboration with NBIC, brought together industry practitioners, interdisciplinary academics and regulatory professionals to discuss sectoral challenges and strategic objectives towards improving efficiency, minimising environmental impacts, and enhancing public perception.

DECEMBER 2022, NBIC PHASE 2
After successful first five years of operation, NBIC was awarded further funding from the BBSRC and Innovate UK for the next five years. NBIC entered its Phase 2 with redefined operations, mission and strategy for future growth.

SEPTEMBER 2023, NBIC SHOWCASE EVENT
NBIC's first showcase event was a celebration which looked back at key achievements from Phase 1, whilst looking forward to exciting plans for Phase 2. The event took place at East Midlands Conference Centre in Nottingham and featured presentations and posters from the NBIC community. Attendees included representatives from our partner research institutions, industry/end-user partners that have contributed to NBIC projects, members of our advisory boards, our Directors, our Operational Team and researchers.

JULY 2023,
HRH The Princess Royal opened a new building, 'the Nucleus', at the University of Edinburgh. An art and physics exhibition showcasing artists' interpretations of biofilms was displayed for the grand opening.

JULY 2023, NBIC INDUSTRY ENGAGEMENT TRAINING
NBIC designed and delivered an industry engagement training event to East Midlands academics interested in engaging with NBIC or the Biotechnology and Biological Sciences doctoral training programme. This event was delivered by NBIC Innovation and Partnership Manager William Green and targeted early career researchers and provided training and advice on areas of industrial unmet need, how to effectively engage with industry and how to design a successful collaborative project.

JULY 2023, NBIC CEO KEYNOTE AT ONE HEALTH CONFERENCE
The One Health 2023 conference, hosted by the Dorset Local Enterprise Partnership (LEP), brought around 100 experts and senior decision makers to Kingston Maurward College near Dorchester to share advice and insight on sustainability and our shared environment. NBIC CEO Jo Slater-Jefferies gave a keynote address titled, Industry, partnership and innovation. The talk highlighted the importance of strategic partnerships across academia and industries and showcased One Health focused projects.

JULY 2023, NBIC SOFTWARE AND COMPUTATIONAL RESEARCH SKILLS TRAINING
NBIC hosted a free Software and Computational Research Skills online training workshop with the Southampton Research Software Group, designed to help researchers gain the skills needed to increase the efficiency and efficacy of their computational skills. The training covered an introduction in how to use Bash, Git, Python and R.

JUNE 2023, BANFF INNOVATION SUMMIT
NBIC's CEO Professor Jo Slater-Jefferies attended the 2023 Banff Innovation Summit in Canada, invited as part of a delegation of international leaders providing their commitment to accelerate investible projects in better agricultural, food and health. Jo is championing the project, 'International Platforms for Bioresource Technologies'.

MAY 2023, BIOFILM SEMINAR SERIES
A new biofilm seminar series, focusing on the interdisciplinary science of aggregated microbial communities and biofilms, launched at the University of Edinburgh. The format of this series is accessible for PhD students and is designed to stay broad enough that researchers from other disciplines interested in biofilms will be able to contribute to the discussion. The seminar series is available online.

MAY 2023, NBIC SHOWCASE: SUPPORTING COLLABORATION FOR IMPACT IN BIOFILM RESEARCH
NBIC and Medilink Midlands organised a productive showcase to support collaboration in the area of biofilm research. During this stimulating and fast-paced morning, our attendees had the opportunity to hear about successful collaborations between academia and industry in the area of biofilm research and innovations.

APRIL 2023, NBIC ARUP ENGAGEMENT EVENT
NBIC's Executive Management Team met with several directors and team leaders in ARUP's Water, Digital and materials teams at ARUP headquarters in london to discuss potential areas of collaboration and began developing several collaborative projects.

MARCH 2023, MICROBIOME ONE-HEALTH CONFERENCE
The Microbiome One-Health conference from Innovate UK KTN explored all things microbiome across the One Health Microbiome spectrum including human, animal, plant, and environment. NBIC CEO, Professor Jo Slater-Jefferies spoke on day 2 of the conference.

MARCH 2023, CHANGE MAKERS LIVE 2023
NBIC Liverpool Director Professor Rasmita Raval attended the business and innovation conference, Change Makers Live 2023, where she delivered a talk on the importance of biofilms. The presentation included an educational piece on beneficial and detrimental biofilms, as well as highlighting the multidisciplinary strength of the NBIC consortium across the UK, and leadership within the global scientific biofilm community.

FEBRUARY 2023, NBIC ATTENDS PATHWAYS TO PRODUCT DEVELOPMENT MEETING
Numerous representations from NBIC took part in the CBE's 'Pathways to Product Development' meeting in Arlington, VA, USA, with Paulina Rakowska delivering an invited talk on the UK's standpoint on biofilm claims and methods in the medical devices sector.

2023

NBIC Highlights

£204M

economic impact of NBIC Phase 1, a benefit to cost ratio of 12.8:1

£11.5M Cash

and in-kind contributions from industry.

5 Spin Outs & 1 Joint Venture

...have been created by NBIC-associated researchers.

43 Intellectual Property

of the NBIC-funded POC and FTMA projects have already reported intentions to explore applications for IP.

Collaborative Training Programme

in biofilms established, with 20 BITE PhD students and 30 studentships from the CTP programme.

102 Jobs

have been created or influenced at our academic and industry partner organisations.

Held 3 Sector-Specific Workshops

including 1 international workshop.

150 Individual Introductions

made linking academic and industry contacts with shared areas of interest or objectives.

430

publications produced in collaboration with NBIC, from over 370 different institutions, with 100 involving 2 or more NBIC research and industry partner institution(s) and 178 involving 1 or more institution(s) based outside of the UK.

13 Position & Policy papers published.

More than 260 UK based companies and 50 internationally based companies engaged.

£37,627

awarded across 15 projects from our Public Engagement and Outreach grant scheme.

FOLLOW

6,620 Followers

across all NBIC social media channels – a 27% increase since our 2022 report was published.

63 Acceded Research Institutions

39 of these have received NBIC POC and/or FTMA funding and 15 have received funding for biofilm-related outreach activities.

150

private, public and third sector organisations

involved with NBIC-funded projects.

246

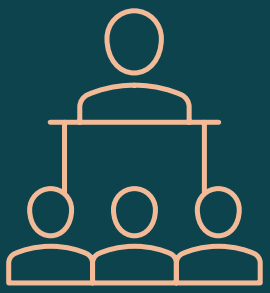
Industrial, research and public partners

have formed partnerships with us via projects, joint applications, and other activities; 37 of which are international collaborations.

11

Interdisciplinary Research Fellows

progressed into permanent roles in industry or academia.



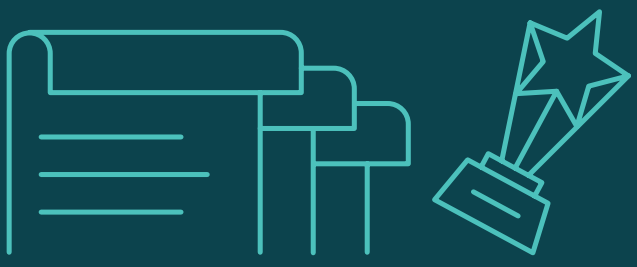
185

Presentations

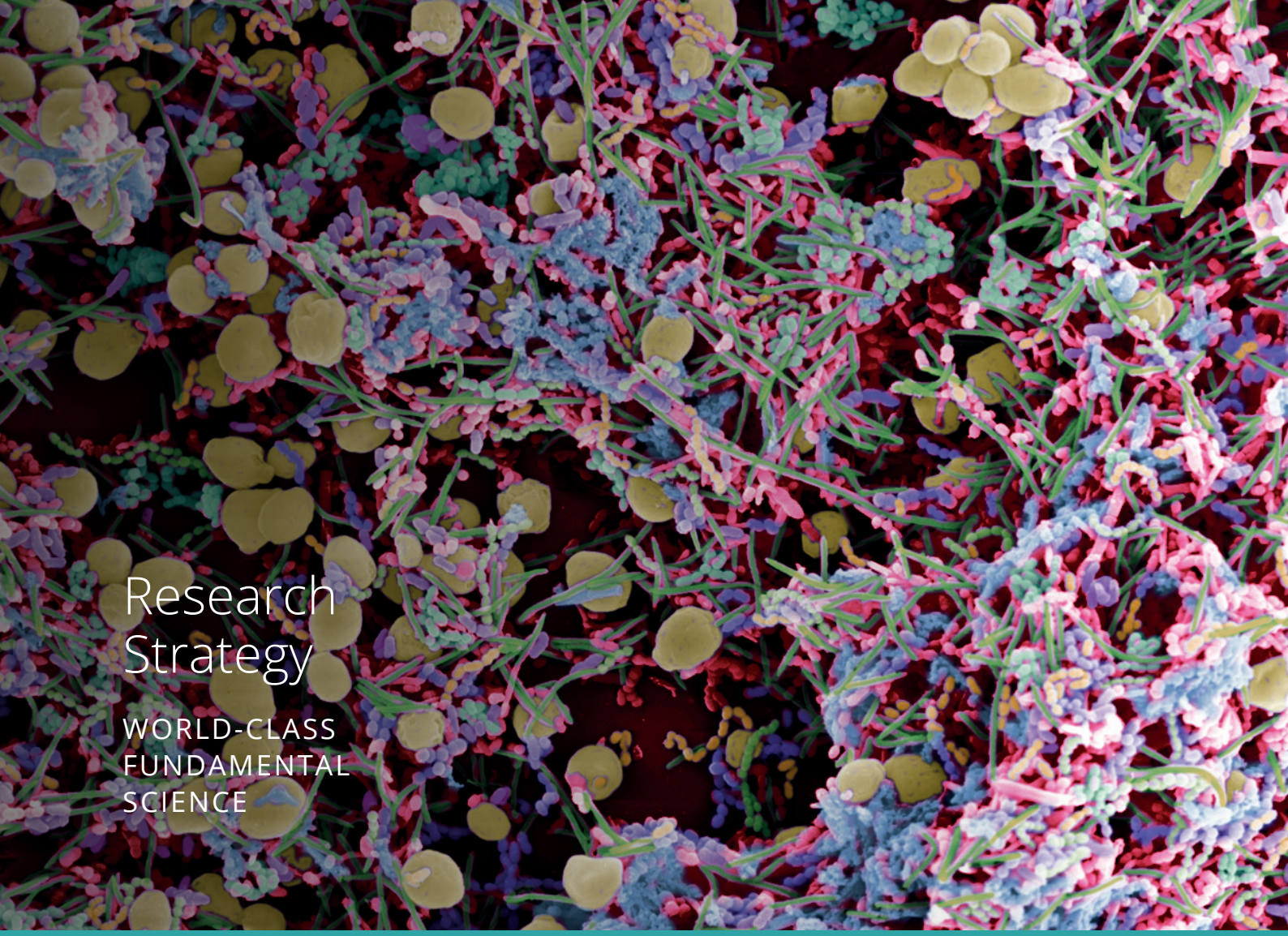
given at Knowledge Transfer Network (KTN), regional body, and national association workshops/meetings, and 20 workshops/ discussions on biofilms standards initiated at UK, EU, and international levels.

Levelling Up

Through POC, Public Engagement and Outreach and FTMA awards, NBIC has provided funding of £3.8M to 66 UK Small and Medium sized businesses.



From 5 FTMA Rounds developed and managed, we awarded 44 projects totalling £582K with cash and in-kind contributions from collaborators of ~£419K.



Research Strategy

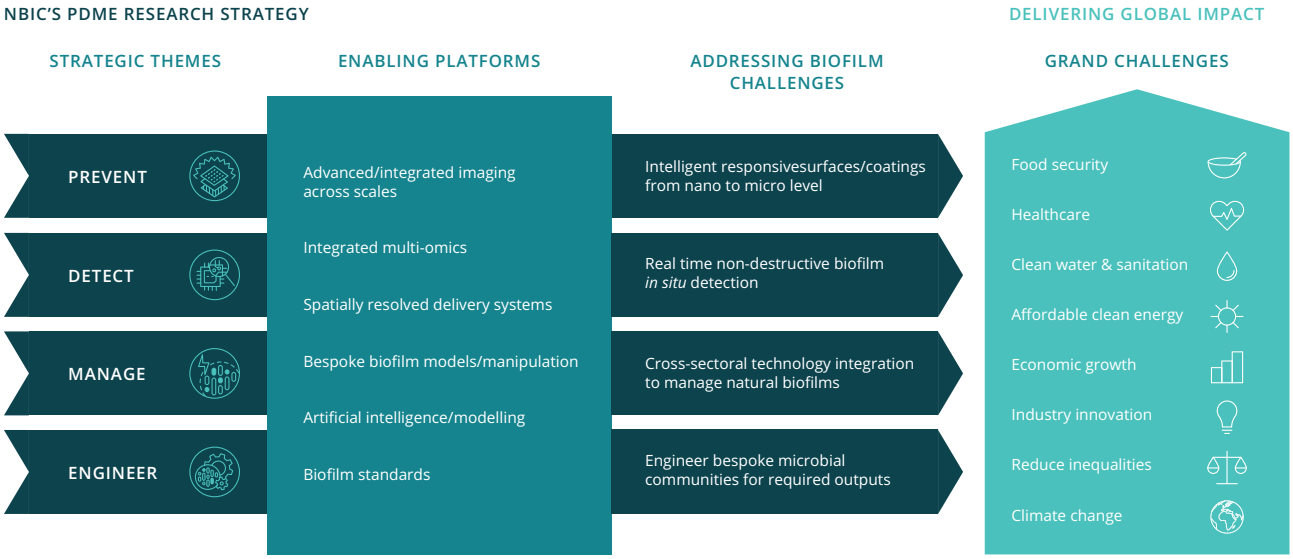
WORLD-CLASS FUNDAMENTAL SCIENCE

Our research strategy for Phase 2 will be dictated by the innovation and impact needed to address cross sectoral and global grand challenges for biofilms. We will embed responsiveness to both emerging UK government strategic priorities, as well as the societal and stakeholder needs that we identify through extensive consultation across our academic and industry partnerships. Challenges and emerging areas where NBIC's technologies will provide transformative impacts in Phase 2 include:

- tackling the onset of infections (hospital-acquired, indwelling medical devices, surgical), mitigation of antimicrobial resistance (AMR), and novel treatments for biofilm-associated chronic infections;
- identifying new biomarker technologies for resistant biofilm infections (recognised by the Life Sciences Industrial Strategy and Life Sciences Sector Deal;
- hygiene and diagnostic platforms for pathogens, in light of the unprecedented awareness from the pandemic;
- energy efficiency, driven by climate change, where challenges include preventing biofouling and microbially influenced corrosion of marine vessels and infrastructure. Future-proofing against the same threats is required for new energy infrastructure e.g. hydrogen transport as the world starts transitioning towards net-zero emissions (Energy Technology Perspectives 2020);
- prediction and mitigation of the impact of climate change on biofilms and microbiomes critical to food and water security;
- mastering engineering microbial biofilm communities to deliver new energy sources, whether through microbial fuel cell and biomass conversion technologies or resource optimisation via aerobic and anaerobic biorefinery;
- establishment of global, harmonised standards in biofilms, and underpinning biobanking and bioresource capabilities to address critical and unmet enabling needs, as consistently identified by our national and international academic-industry road-mapping.

Interventional Themes

PREVENTION, DETECTION, MANAGEMENT AND ENGINEERING OF BIOFILMS (PDME)

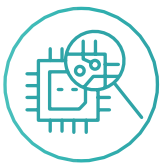


Over the past 5 years we have established a national research agenda addressing the PDME themes in collaboration with our academic and industry partners and in consultation with end users. Our thematic and sector roadmaps identify a clear path to successful creation of value from biofilm research. Our model harnesses NBIC's world class underpinning research and infrastructure by dedicating the resource of our Interdisciplinary Research Fellows (IRFs), who support the NBIC fundamental research and training strategy (60%), connecting this knowledge with industry by working collaboratively on R&D projects (40%). We will address cross-cutting biofilm technology challenges across PDME which have been identified through our engagement activities: (i) A linked platform of integrated imaging techniques across scales (from atoms to biofilm communities) integrating physical, engineering and life sciences; (ii) Real-time, non-destructive monitoring and advanced imaging technologies and biomarkers for biofilms, available for clinical use and competitively across industrial process applications; (iii) Integrated multi-'omics to understand polymicrobial interactions within biofilms; (iv) Spatially resolved and addressable delivery and monitoring of new interventions within biofilms; and (v) *De novo* engineering of polymicrobial communities for targeted, sector-specific applications, with particular emphasis across health, sustainability, net-zero carbon emissions and hygiene in a post-pandemic world. These state-of-the-art enabling platforms will deliver transformative impact in biofilm research and innovation across our PDME themes.

PREVENT

Lead Organisation:
University of Liverpool

Focuses on mapping and controlling mechanisms that govern microbial adhesion and colonization at surfaces by deploying advanced interdisciplinary techniques.



DETECT

Lead Organisation:
University of Southampton

Focuses on the need for accurate, quantitative biofilm detection and metrology across multiple scales, through innovative sensing, tracking and diagnostic technologies.

MANAGE

Lead Organisation:
University of Nottingham

Focuses on understanding the mechanisms governing biofilm life cycle dynamics and development, physicochemical properties, levels of complexity and their interactions with the environment with a view to interfere with these in a targeted manner.

ENGINEER

Lead Organisation:
University of Edinburgh

Focuses on the control of biofilms in industrial environments and large-scale infrastructure, and the engineering of bespoke biofilms for targeted applications, harnessing the benefits of synthetic biology tools and approaches.

Data Management

Research data management at NBIC is an ever-growing requirement to make research, and the data derived from it, open and accessible. When planning our research or developing applications for funding, we work to create effective planning, collection, organisation, storage, preservation and sharing of our data during and beyond the lifespan of the research project.

By following our funders' data management policies and requirements, we create simplistic strategies to facilitate data organisation and warehousing. In addition, through our productive relationships with our research management team in our library services, we can exploit our institutional data repositories that provide us with appropriate guidance on data warehousing and DOIs, hence, ensuring data safeguarding during the research cycle.

Economic Impact

THE ECONOMIC SIGNIFICANCE OF BIOFILMS

ECONOMIC SIGNIFICANCE OF BIOFILMS STUDY

INTERNATIONAL BIOFILM MARKETS PAGE

Wherever microbes either cause a problem or create an opportunity, to humans, animals or the environment, then the communities in which they live (biofilms) have a role to play. NBIC carried out a study to quantify the value of the markets in which biofilms are involved. The study titled **Economic significance of biofilms: a multidisciplinary and cross-sectoral challenge** was published in *NPJ Biofilms and Microbiomes* in 2022. We conservatively estimate this is £45bn in the UK and $4tn globally.

Our study has shown that although biofilms are diverse in their impacts on humans, animals and the environment, there are scientific and technological challenges that are common to many sectors as described in the NBIC interventional themes of Prevention, Detection, Management and Engineering. These common challenges underpin the need for the research and innovation occurring across all these sectors to be well connected as a community via NBIC, so that early breakthroughs can be exploited, and solutions from one sector considered in other fields. We exist to match solutions and needs in an effective and efficient manner. This is critical in order to achieve economic and societal benefits as well as developing the skills and knowledge scientists and technologists need to understand and solve both problems and the opportunities.

We created eight infographics to reflect the results of this study, and to show the huge impact that biofilms have on our global economy. You can download the infographics and access the study from the **International Biofilm Markets page** on our website. Please scan the QR code to access the page.

NBIC's Economic Impact

A new economic review, from Black Kite Ltd, highlights a number of significant impacts following the £16m investment from BBSRC and Innovate UK into NBIC between December 2017 and December 2022, demonstrating a total impact of approximately £204m that extends throughout the UK economy.

Our Proof of Concept projects have demonstrated environmental and social benefits, estimated at £23m and £30.5m, respectively.

A key outcome found in the economic review is job creation, with fifty-one positions established, including secondments, research posts, and jobs at spin-out companies. Furthermore, our influence has contributed to the creation and development of an additional fifty jobs. NBIC has been instrumental in nurturing talent, with seventy-six students benefiting from support, including sixty-six PhD candidates, six of whom are international students.

Our core universities (Edinburgh, Liverpool, Nottingham and Southampton) have attracted an additional £32.9m of public and private funds, which is estimated to have an economic output of almost £43m so far, with a greater economic value still to be realised as the additional research funds are used. In addition, clusters of biofilm activity within the regions of the NBIC associated universities have attracted further public and industry funding, with an estimated total impact of £8.1m.

We have established international partnerships with renowned institutions such as the Centre for Biofilm Engineering in Montana and the Singapore Centre for Environmental Life Sciences Engineering and have played a leading role in forming the International Biofilm Standards Task Group. More information on these initiatives can be found in the next section of this report.

The further £7.5m investment from BBSRC and Innovate UK will enable NBIC to drive the adoption of innovative solutions across industry sectors to address major global challenges including climate change, water safety and improved healthcare. It will also drive step-changes in standards and regulation for novel biofilm solutions that support international trade.

UKRI recently commissioned an **independent review into the IKC programme** to gain an understanding of the programme's impact to date, feedback on the scheme and recommendations for future evolution, which evidences further NBIC's contribution to research and innovation in the UK.

AN INDEPENDENT REVIEW INTO THE IKC PROGRAMME

International Strategy

FACILITATING INTERNATIONAL ENGAGEMENT AND COLLABORATION IN BIOFILMS

The overall goals and strategic intent of NBIC's international collaborations are to leverage our current position within the global scientific biofilm community and prioritise outreach to key developed and emerging regions. Our international strategy strives for:

- Working with biofilm academic centres that are prominent and endeavour to advance the field. We build on our existing relationships with India, Singapore and the US, to explore academic, industrial and regulatory synergies.
- Establishing international industrial contacts where these can stimulate the growth of the UK science and industrial base in translational biofilm research. As an example, in October 2022 we co-organised, with the Argentinean Society for General Microbiology (SAMIGE), a workshop titled 'Biofilms in Agriculture' aimed at bringing together key researchers and industry representatives from both countries to catalyse collaborations in the area of plant-microbial interactions and sustainable crop production.
- Acquiring new contacts in other regions supported by international grants for the developing world. Supported by the funding from BBSRC we will be holding an international workshop, in October 2023, to establish a new synergistic partnership between NBIC and the West African Centre for Cell Biology of Infectious Pathogens (WACCBIP) in Ghana in the areas of biofilms biobanking and antimicrobial discovery.
- Representing the UK biofilm community at international biofilm networks, such as the European COST Action on Microbiologically Influenced Corrosion (Euro-MIC) aimed at a creating a synergistic collaboration and communication between materials scientists, engineers, microbiologists, chemists and integrity managers from academia and industry to create more sustainable, safe and reliable MIC management practices.
- Commitment to accelerate investible projects in better agricultural, food and health. NBIC's CEO Professor Jo Slater-Jefferies attended the 2023 Banff Innovation Summit in Canada, invited as part of a delegation of international leaders. Jo is currently championing the project, 'International Platforms for Bioresource Technologies'.

Our aim, as a consortium of 63 UK research organisations, is to become a strong partner to a larger, more powerful and influential international network of industry and academic partners.

INTERNATIONAL BIOFILM STANDARDS TASK GROUP

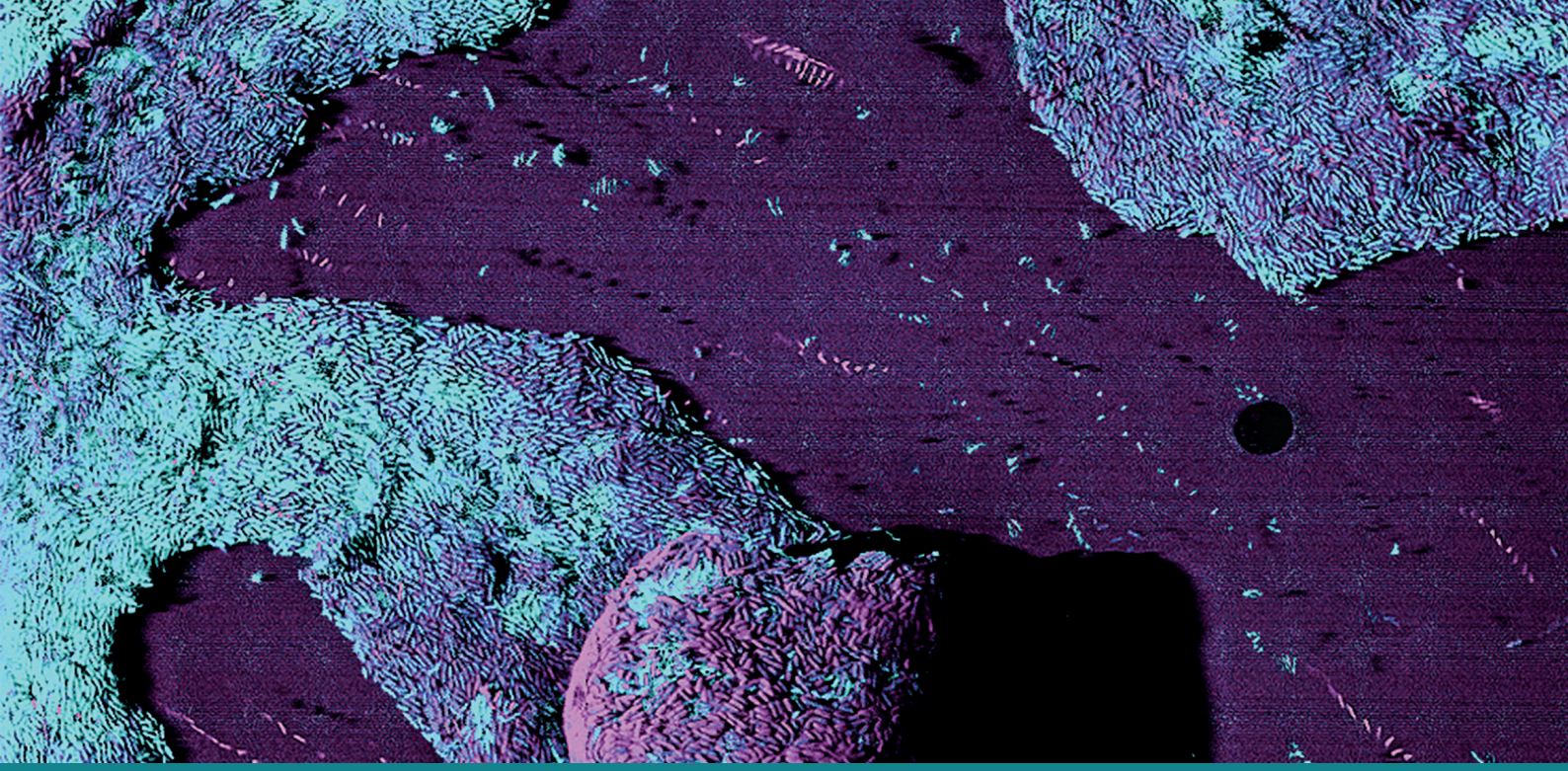
Driven by industry needs, in February 2020, NBIC, along with the USA Center for Biofilm Engineering, the Singapore Centre for Environmental Life Sciences Engineering (SCELSE), and an EU Cooperation in Science and Technology (COST) action group, formed an International Biofilms Standards Task Group (IBSTG). Its mission is to drive the international development and acceptance of standardised biofilm test methods in healthcare, the built environment and industrial systems and enable informed and consistent decision making on the international regulation of anti-biofilm products.

ACHIEVEMENTS AND PROGRESS TO DATE

- In June 2020, NBIC joined the BSI CH/216 Chemical Disinfectants and Antiseptics Committee to lobby for development of standards for assessment of these agents in the presence of biofilms.
- In December 2020, NBIC secured funding from the UK Department for Business, Energy and Industrial Strategy (BEIS) to progress the development and characterisation of standardised biofilms with a view to developing a joint platform methodology with SCELSE in Singapore.
- In September 2021, the IBSTG led a session at the International Biodeterioration and Biodegradation Symposium (IBBS) on 'Closing the gap: the role of regulatory standards in biofilm research & industry innovation'.
- In February 2022, NBIC and SCELSE participated in the UK-Singapore Strategic Dialogue in Science and Innovation, where they urged for a joint and collaborative programme on biofilm standardisation.
- In March 2022, a working group CH/216/3 Biofilms and Products was established, under the BSI CH/216 Committee and chaired by NBIC, which set out to explore new areas of biofilm standardisation.
- In April 2022, NBIC in partnership with the USA Centre for Biofilm Engineering (CBE), organised a workshop on Biofilm Regulations and Standardisation in the medical device and pharma sectors.

FUTURE PLANS

The IBSTG is conducting a global biofilm methods and standards review covering various regions and industry sectors, with several publications in preparation with the aim of setting up a central database of all current methodologies and standards that exist in each sector and the terms they use for biofilms e.g., 'slime', and the 'microbiome'. Such a review will provide a basis for gap analysis and identify the standards which are most needed by the community.



Priority Questions

FOR MICROBIAL BIOFILMS

The Priority Questions for Microbial Biofilms Exercise is a joint venture between NBIC, the Center for Biofilm Engineering (CBE), Singapore Centre for Environmental Life Sciences Engineering (SCELSE), COST AMiCI Consortium and the ESCMID Study Group for Biofilms (ESGB). We called on the international biofilm community to help us identify priority questions that, if answered, would make a considerable impact on the fundamentals of the field of microbial biofilms, to innovation in approaches to prevent, detect, manage and engineer biofilms, or which would be expected to have an impact in influencing policy makers and funders.

To date, there has not been an international and community-wide synthesis of key questions and priority research or innovation areas for the biofilm field. Such exercises can play a critical role in bridging the gap between the data generated by researchers, and the information needed by policymakers to make funding or regulatory decisions. We called for questions that are unanswered, could be answered (including through high-risk and blue-skies research), and that could be tackled by a research programme.

Participants were asked to submit their questions anonymously in April 2021 and were also given the option to leave their contact details if interested in participating further with the activity. We received 309 questions in total, from across every continent, totalling 31 countries.

The position paper is anticipated to be published soon, as a resource for the field. This is expected to help set the agenda for future research in the field of microbial biofilms as well as have impact in areas of policy and outreach.

CONTACT NBIC TO REQUEST A PARTNER SEARCH

BIOFILMS & BARRIER TECHNOLOGIES: THE FUTURE OF COMMERCIAL CLEANING

Industry Engagement

WORLD-CLASS FUNDAMENTAL SCIENCE

NBIC exists to expand, catalyse and harness the UK's academic and industrial strengths in biofilms for the benefit of the UK. We aim to deeply understand unmet needs in our industrial partners' contexts and markets.

Through ongoing engagement, we then aim to demonstrate the ability of NBIC research partners to address these needs, hence driving opportunities for industry and academic collaboration, investment and income.

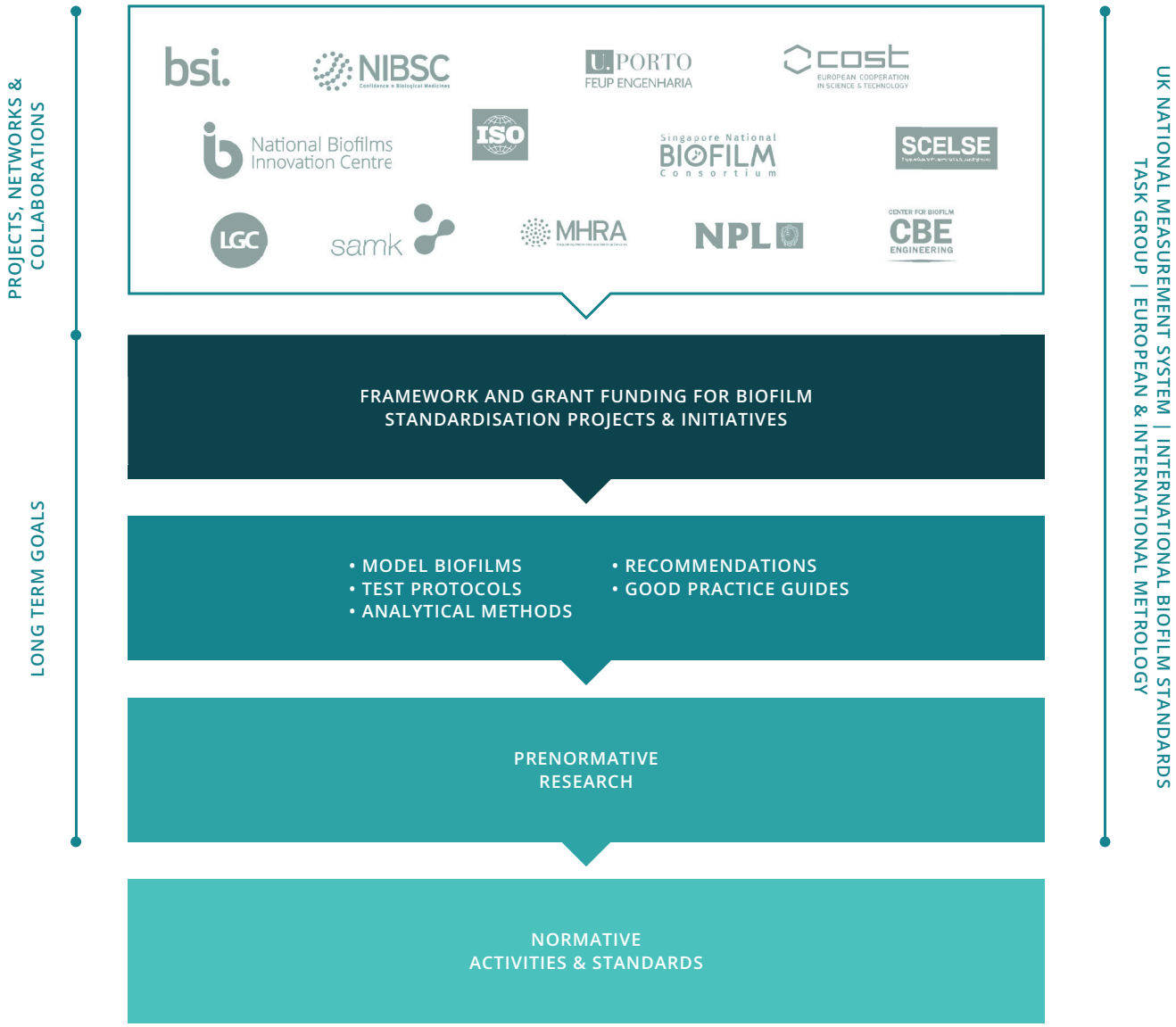
Our strategy is to match unmet industrial biofilm needs with possible solutions in order to become an essential part of our industrial partners' network or open innovation pipeline. We listen, understand, and explore needs and/or capabilities, and then create and support connections. We also find ways of progressing these connections either through our own funding routes (Proof of Concept calls) or helping signpost to other opportunities.

Our partner searches aim to 'match-make' a need to an opportunity or solution (bilaterally between industry and academics) either via a personal contact through our innovation team or emails targeted to our wide network. Contact us at **nbic@biofilms.ac.uk** to request a partner search.

In February 2023, we published a whitepaper entitled **'Biofilms & barrier technologies: The future of commercial cleaning,'** in collaboration with specialist cleaning service provider, REACT Specialist Cleaning. The report provides three examples of real barrier-tech products that cleaning operatives can use in public spaces. It also provides professional advice related to buying effective products and using them correctly. NBIC is bringing together companies like REACT, as well as academics, manufacturers and regulators to fast track the development of new effective treatments to prevent and remove biofilms.

Establishing Global Standards in Biofilms

NBIC STANDARDISATION ROADMAP



A critical unmet need for innovation across industry sectors is the infrastructure and support needed to demonstrate alignment to relevant standards and the associated analytical competencies. Our national and international academic-industry road-mapping has consistently identified the establishment of global standards in biofilms as a priority need.

NBIC is actively addressing this need by establishing networks and collaborations and engaging in a variety of initiatives and research projects with the aim of supporting academic and industry communities in developing biofilm standards and influencing regulations:

- The International Biofilm Standards Task Group (IBSTG), a multicentre collaboration between NBIC, the USA Center for Biofilm Engineering, the Singapore Centre for Environmental Life Sciences Engineering (SCELSE), and an EU Cooperation in Science and Technology (COST) Action Anti-Microbial Coating Innovations to Prevent Infectious Diseases (AMiCI), was formed in 2020 to guide the international development and acceptance of standardised biofilm models and test methods in healthcare, environment and industry.
- BBSRC-funded partnering awards.
- Participation in and a seat on the management committee of the EU COST Action: Euro-MIC 'European Microbially Influenced Corrosion Network – New Paths for Science, Sustainability and Standards'. We also co-developed a proposal for a COST action tackling the reproducibility of biofilm-related methods.
- Co-organisation of a focus session on biofilm standardisation, at the 18th International Biodeterioration & Biodegradation Symposium (IBBS) at Montana State University, USA in September 2021.
- Membership of the British Standard Institute (BSI), contributing to the CH/216 committee on 'Chemical Disinfectants and Antiseptics', and working group CH/216/3 on Biofilms and Products aiming to explore possible new areas of standardisation work. Similarly at the European level, participating in the European Committee for Standardization (CEN) TC 216 WG 5 Strategy Group - Biofilm Task Force.
- Research collaborations with the UK's National Measurement System institutes include:
    1. The development of biofilm reference materials with the international life sciences measurement and tools company LGC, funded by NBIC's POC4 programme.
    2. Collaboration with the National Institute for Biological Standards and Control (NIBSC), part of the Medicines and Health Regulatory Agency (MHRA), on the development of biofilm preservation technologies.
    3. Piloting the development of reproducible biofilm models and analytical methods in collaboration with the National Physical Laboratory (NPL).
- Building awareness of biofilm standardisation through presentations and posters at conferences and meetings.
- Developing, reviewing and providing input to biofilm standards under the Association for Materials Protection and Performance (AMPP). Currently working on three biofilm-related standards in the fields of biocides, oil and gas systems and microbiologically influenced corrosion.
- Undertaking reviews and gap analysis. In 2022, NBIC commissioned a review of methods and standards to support anti-biofilm claims in medical devices sector, which will be soon published.
- Influencing policy. As an example, on 19 October 2022, NBIC's CEO pitched to the (then) UK Commons Science and Technology Committee, at a 'My Science Inquiry' event, on the importance of biofilm standards and regulations.

Workshops

KEY FINDINGS

BIOFILMS IN AGRICULTURE

A workshop on biofilms in agriculture took place in Los Cocos, Córdoba, Argentina on October 24, 2022, through the joint efforts of NBIC and a team of Argentine researchers. The event was organised within the framework of the SAMIGE (Argentinean Society for General Microbiology) annual congress and received financial support from a BBSRC Global Partnering Award.

In the agricultural sector, biofilms are utilised as biofertilisers, biostimulants, soil bioremediators, and biocontrol agents. Despite their potential benefits, there is still much to learn about the complex interactions between biofilms and plants, and how to harness these interactions for enhanced plant growth and disease prevention. A deeper understanding of biofilms in this context is essential for effectively managing and directing microbial communities towards creating a sustainable environment. NBIC and Argentine researchers from academia and industry have established a dialogue aimed at addressing these gaps and improving agricultural productivity through the integration of new technologies that can promote soil health whilst reducing environmental impact.

The objectives of the meeting were to:

- Bring together complementary academic / industrial expertise from these countries on exploitation of biofilms in agriculture to identify key knowledge gaps and research challenges in this area of agricultural impact.
- Create future research collaborations on the use of biofilms in crop production between the UK and Argentina.

Three priority areas for collaborative activity were identified through the discussions:

- Using plant root biofilm composition as a sensor for soil health and to optimise interventions.
- Biofilms and soil health resilience in a changing environment.
- Intelligent seeds and innovative / automated large-scale monitoring systems.

Future research collaborations between the two countries in this area could have significant benefits for global agricultural innovation and the development of sustainable food systems. For the three identified priority areas, the early engagement of end-users (farmers) will be paramount to maximise technology adoption. Commitment from the governments and support from funding bodies in both countries will be essential for the establishment of robust research programmes and long-term successful collaborations between researchers, industry and end users.

NBIC published a detailed report from the workshop, and have also produced a white paper, describing the discussions and recommending the identified priority areas for the UK – Argentina collaboration, which has been submitted to CABI Agriculture and Bioscience Journal.

BIOFILM REGULATIONS AND STANDARDISATION IN THE MEDICAL DEVICE AND PHARMA SECTORS

NBIC, in partnership with the USA Centre for Biofilm Engineering (CBE), organised a workshop on Biofilm Regulations and Standardisation in the Medical Device and Pharma sectors, which took place in Birmingham, UK, on 29 April 2022. The meeting was supported by a BBSRC Global Partnering Award.

The meeting was unique, bringing together over 40 representatives from industry, academia, metrology and standardisation and regulatory bodies to map the current landscape, needs, trends and expectations in biofilm standardisation within the UK and to establish industry and regulatory participation in a forward working group. Discussions were very candid, open and stimulating, with the aim of working together as a community to advance the field. The presence of international delegates was very useful and provided additional context to the discussions. Participants were asked to consider and debate two questions:

- What do you see as the current needs with respect to standards and regulations in your setting and business relating to biofilms?
- What do you believe should be (i) done in terms of concrete next steps by this group? And (ii) the overall long-term goals?

The participants shared a plethora of different experiences, needs, ideas and unique views on the subject. Nevertheless, several clear points emerged, both from the pre-work feedback and from the in-person discussions:

- There is both the opportunity and desire from the community to make progress in creating biofilm-related standards.
- There is a strong need for a comprehensive review of standards, methods and practices that are currently in use by the community. Such a review would provide a basis for a gap analysis and identification of a pathway for biofilm standards development.
- It is clear that 'one size will not fit all' due to diverse sectors and applications and the complexity of the biofilms themselves. It would be more practical to build a 'component approach', consisting of a base set of standards and guidance on how and when to use them.
- It is crucial that regulators are part of the standardisation activities and engaged from the beginning.

INTERDISCIPLINARY WORKSHOPS

The five interdisciplinary workshops we designed and led have seen 236 attendees with an approximate mix of 60:40 academics and industry partners. These have all taken the format of exploring the key unmet needs from industry, how the current state of the science and technology landscape could address these requirements and, in doing so, developed a shared understanding of the opportunities and challenges. The outputs from our five workshops are summarised below. Four of these represent our key strategic themes: Prevent, Detect, Manage and Engineer. The fifth is a workshop we ran on Microbe - Metal Interactions in conjunction with the Center for Biofilm Engineering.

BIOFILM PREVENTION

In 2021, NBIC held a workshop aimed at exploring unmet industrial needs and resulting research questions in the field of biofilm prevention. Prevention relates to impacting the early stages of microbial adhesion and colonisation events at surfaces and the curtailing of the development of early-stage biofilms so that surface performance is retained. In many commercial fields (e.g., medical, marine and the built environment) this is a primary need and is one of the key purposes of their products, for example to prevent colonisation of indwelling or implantable medical devices. It is clear the question concerning the best approaches to prevent biofilm formation remains a significant challenge to both academics and industry. Common approaches are aimed at modifying the surface topology or chemistry of the target item or surface. This has resulted in what remain a number of unmet or poorly met needs in the field of biofilm prevention which were explored at the workshop.

Key needs that emerged were:

- The lack of suitable biofilm model systems to evaluate the impact of new approaches in the lab that are relevant and predictive for the end setting. It is clear that an improved understanding of the factors promoting or inhibiting biofilm formation is needed, and how this varies with different species. A much deeper understanding of the early colonisation mechanisms leading to biofilm formation is also required.

- Knowing how to sustain the impact of a surface treatment with time and as it consequently becomes conditioned by its local environment.
- Developing innovative approaches for biofilm prevention that have the cost and scale needed for end market use (e.g., contrast the scale of surface treatment needed for an implanted pacemaker with the treatment of a whole cargo ship, which are both intended to prevent biofilms).
- Improved translational funding and activities to assess the benefits of novel interventions in real world or model systems relevant to the end use.
- Standards: as with other areas in the field of biofilms there are a lack of standard methods for testing and claims generation and often a large difference between academic and industry models, equipment, skills and practice.

At the workshop, there was a consensus that NBIC was well placed to influence the direction of research in this area, to enhance interactions and collaboration between academia and industry, and to be involved in arguing for the creation of uniform associated standards and methods for testing and claims generation.

BIOFILM DETECTION

Unmet needs:

- Rapid, *in situ*, point-of-use context for a range of new and emerging technologies.
- Biomarkers that are definitive for biofilms (e.g., blood, industrial fluids, other secondary media).
- To detect/characterise when a biofilm transitions from a 'healthy' to an 'unhealthy' or 'pathogenic' state.
- To detect and confirm the presence of a biofilm in a standardised reproducible manner acceptable to regulatory agencies.

BIOFILM MANAGEMENT

Unmet needs:

- Improved models and methods for the characterisation, visualisation and detection of biofilms; relevant (real world context), standardised and accessible.
- Improved cross-disciplinary collaboration (industry, academia, regulators and cross-sectors).
- Clarification of pathways from industry regulators. NBIC has a leading role to play here.

Challenges to overcome:

- Fundamental research on understanding biofilm behaviour and control to give us new leads and insights is required.
- Data centralisation and management.

BIOFILM ENGINEERING

Unmet needs:

- The need to engineer biofilms for benefit(s) in a human or an animal.
- Creation of a bespoke biofilm community for a defined process, outcome or benefit.
- Improved approaches for investigating, enhancing, monitoring or studying biofilms in the engineering setting.

Challenges to overcome:

- Developing improved model systems.
- The development and standardisation of experimental and monitoring methods including real-time, high throughput, large scale and multi-variable.
- Improved methods for the manipulation of an existing biofilm are critical to achieve relevant end products or results.

MICROBE-METAL INTERACTIONS

Unmet needs:

- Achieving improved risk assessment, prediction, and modelling.
- The elucidation of coupled microbial metabolisms and potential novel biomarkers.
- Improved understanding of the interplay between microbes and the surface may lead to identifying key markers.
- Creating improved methods for the detection of biofilms and monitoring of systems.
- Identifying improved concepts to prevent biofilm formation.

Key areas of emerging science:

- Mechanisms and models of metal-microbe interactions.
- Technologies for understanding the metal surface with the ability to measure, interrogate, visualise and modify it.
- The need for early detection and monitoring of biofilm formation and MIC occurrence.
- Approaches that enhance a surface's ability to prevent biofilm formation are critical to addressing unmet needs.

The connections and support we create via our workshops, visits and partnering can lead to a range of collaborations including fully funded joint projects between a company and an academic, a fruitful long-term relationship or even an application to one of our proof of concepts (POC) calls.

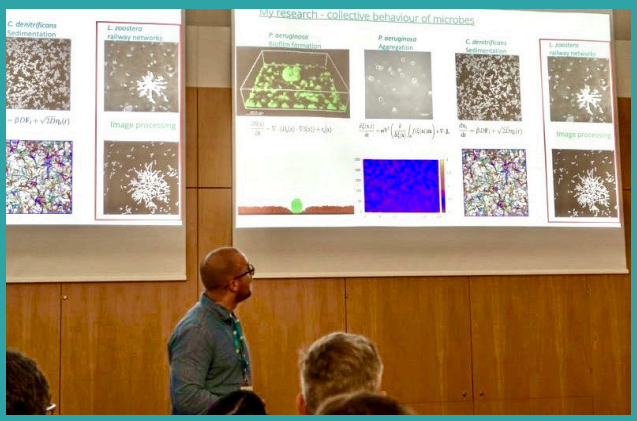
Our Tableau map pinpoints the international reach of NBIC events including conferences, workshops, webinars and training sessions.

TABLEAU MAP

Regional Events

WASTEWATER TREATMENT EVENT

Wastewater treatment (WWT) is arguably the most important biotechnological process in world. The science behind WWT is well-established and has been in use for more than 100 years, yet unexplained and costly failures happen regularly and unpredictably. With increasing public awareness, and regulatory and sustainability pressures, plus the threat of rising sea levels on coastal WWT plants, the sector is at a crossroads, requiring an injection of fundamental understanding in order drive disruptive innovation. This Edinburgh Complex Fluids Partnership (ECFP) event, run in collaboration with NBIC, brought together industry practitioners, interdisciplinary academics and regulatory professionals to discuss sectoral challenges and strategic objectives towards improving efficiency, minimising environmental impacts, and enhancing public perception. The event took place from 15-16 November 2022. The aim of the event was to increase awareness of how soft matter and biological physics could be applied in WWT and to identify joint problems across industry, academia and regulators that could be worked on together.



CHANGE MAKERS LIVE 2023

On 2 March 2023, NBIC Liverpool Director Professor Rasmita Raval attended the business and innovation conference, Change Makers Live 2023, where she delivered a talk on the importance of biofilms.

The presentation included an educational piece on beneficial and detrimental biofilms, as well as highlighting the multidisciplinary strength of the NBIC consortium across the UK, and leadership within the global scientific biofilm community. Change Makers Live is a national conference, hosted by Downtown in Business, exploring innovative solutions to the challenges facing the UK and global economy in the twenty-first century. The 2023 event in Liverpool gave leading entrepreneurs, academics, opinion formers, and politicians a platform to offer solutions to the key issues that are exercising decision-makers not just in the UK, but around the globe. Both Gillian Keegan, Secretary of State for Education, and Wes Streeting, Shadow Secretary of State for Health and Social Care, addressed the conference.

SUPPORTING COLLABORATION FOR IMPACT IN BIOFILM RESEARCH

NBIC and Medilink Midlands organised a productive showcase to support collaboration in the area of biofilm research, which took place on 17 May 2023. During this stimulating and fast-paced morning, our attendees had the opportunity to hear about successful collaborations between academia and industry in the area of biofilm research and innovations. Different projects were presented by our panel of experts and our attendees had the unique opportunity to network and pitch their ideas for new collaborations. A guided tour through our facilities gave our delegates the great opportunity to learn about the vast range of technologies based at NBIC Nottingham. In addition, NBIC and Medilink had the honor to launch an Innovation voucher call targeting all SMEs from the Midlands area. From this call, two projects were selected to make use of NBIC facilities that aimed to contribute to the development of their technologies.

BIOFILM SEMINAR SERIES

A new biofilm seminar series, focusing on the interdisciplinary science of aggregated microbial communities and biofilms, launched at the University of Edinburgh on 17 May 2023. In the inaugural seminar, NBIC Edinburgh Co-Director Professor Cait MacPhee and Professor Nicola Stanley-Wall from the University of Dundee spoke on their complementary work on *Bacillus subtilis* biofilms from two different disciplines. The format of this series is accessible for PhD students and is designed to stay broad enough that researchers from other disciplines interested in biofilms will be able to contribute to the discussion. The series will continue throughout 2023 and will continue to be accessible online. It is anticipated to include academics from all different disciplines and fields working on biofilms as well as industry representatives. The series was established by Chancellor's Fellow and NBIC Interdisciplinary Research Fellow Gavin Melaugh.

ONE HEALTH CONFERENCE 2023

One Health is an approach (for policy, strategy, and business) which recognises the interconnectedness of human, animal, plant, and the wider environmental health, and seeks innovations to meet the challenges caused by our changing environments. The One Health 2023 conference, hosted by the Dorset Local Enterprise Partnership (LEP) on 13 July 2023, brought around 100 experts and senior decision makers to Kingston Maurward College near Dorchester to share advice and insight on sustainability and our shared environment. Attendees included business leaders, scientists, policymakers and investors keen to support solutions for climate change, pollution and disease. NBIC CEO Jo Slater-Jefferies gave a keynote address titled, Industry, partnership and innovation. The talk highlighted the importance of strategic partnerships across academia and industries and showcased One Health focused projects. It was agreed that a steering group will be formed in autumn 2023 to progress a One Health Enterprise Network (OHEN), to champion and promote a One Health approach to enterprise and growth and to help companies and organisations in all disciplines touching on human, animal, plant or environmental health.

INDUSTRY ENGAGEMENT TRAINING EVENT 2023

NBIC designed and delivered an industry engagement training event to East Midlands academics interested in engaging with NBIC or the Biotechnology and Biological Sciences doctoral training programme. This event was delivered on the 7th of July by NBIC Innovation and Partnership Manager William Green and targeted early career researchers and provided training and advice on areas of industrial unmet need, how to effectively engage with industry and how to design a successful collaborative project.

Training

BUILDING ENTREPRENEURIAL SKILLS

TRAINING NEED

- DEPTH AND BREADTH ACROSS DISCIPLINES
- PROBLEM-SOLVING IN MULTIDISCIPLINARY TEAMS
- WORLD LEADING SCIENTIFIC RESEARCH AND KNOWLEDGE
- OPPORTUNITY TO WORK ACROSS NATIONAL AND INTERNATIONAL SITES
- ENTREPRENEURSHIP, INNOVATION, IP TRANSLATION
- LEADERSHIP MANAGEMENT
- RESPONSIBLE INNOVATION
- COMMUNICATION, IMPACT, OUTREACH
- EMPLOYABILITY

PREVENT

Knowledge-based design of surfaces, interfaces and materials

DETECT

Innovative sensing, tracking and diagnostic technologies

MANAGE

Kill, remove or control established biofilms from exploiting their life cycle dynamics

ENGINEER

Control and direct complex microbial communities in process applications

WORLD-CLASS RESEARCH PLATFORMS

- AMR
- 'OMICS AND BIOINFORMATICS
- FUNCTION & ACTIVITY
- COMPLEX COMMUNITY INTERACTIONS
- INTERFACIAL INTERACTIONS
- PREDICTIVE MODELLING
- NEXT GENERATION IMAGING & SENSING
- ENGINEERED INTERFACES AND MATERIALS
- BIG DATA

SECTORIAL CHALLENGES

- IMPROVED HEALTH
- GROWTH THROUGH BIOTECH AND BIO-REFINERY
- PREVENT CORROSION AND BIOFOULING
- NEXT GENERATION ENABLING TECH
- IMPROVED CONSUMER PRODUCTS
- SAFE FOOD

NBIC BITE INTRODUCTION TO COMMERCIALISATION CPD PROGRAMME

The 'Introduction to Commercialisation' programme comprised of a 4-half day cohort workshop to introduce doctoral candidates to innovation, entrepreneurship, the basics of business acumen, how to build collaboration and networks and, overall, to encourage delegates to see things from different perspectives. Our intent was to keep this programme 'gentle' and informative but also a fun introduction to various aspects of the commercialisation process that doctoral candidates are likely to experience in their future work and career. So far, 49 students have been through the training programme and have found the content extremely useful to their professional development.

NBIC SOFTWARE AND COMPUTATIONAL SKILLS WORKSHOP

The 'NBIC Software and Computational Skills Workshop' was held over 7 half-day sessions and was facilitated by the Southampton Research Software Group. The workshop was designed to help researchers gain the background and practice required to increase the efficiency and efficacy of their computational skills. During this workshop, attendees learned the basics of using text-based interface with a computer to automate tasks with the Unix Shell. They also learned how to track changes in Git, to enable more effective teamwork and collaboration. Additionally, researchers learned the basics of the Python programming language and learned how to build programs using Python. Lastly, researchers learned the basics of the R programming language and learned how to perform data analysis and how to create visually engaging plots. These skills will allow researchers to more effectively communicate their scientific findings.

NBIC TECHNICAL MODULE – MICROBIOLOGY: FROM CELL BIOLOGY TO BIOFILMS

The University of Nottingham hosted NBIC BITE and CTP students for a technical training module where they were introduced to concepts including microbial physiology, the mechanisms of biofilm formation and interactions between different microorganisms within polymicrobial biofilms. Students also learnt about different biofilm models, imaging techniques, antimicrobial targets and mechanisms of antimicrobial resistance. This week-long module offered networking opportunities for students with other PhD researchers but also with biofilms experts at the University of Nottingham and industry representatives.

NBIC provides entrepreneurial training for early career researchers and established academics. We have strong links to:

ALDERLEY PARK ACCELERATOR

The on-site incubation and acceleration team specialises in the start-up and scale up of biotech and life science businesses by providing the programmes, networks and support required for success. NBIC has jointly run a pre-accelerator programme for our community as a prelude to offering a full follow-on 8-week accelerator programme for the best performing pre-accelerator Early Career Researchers and academics selected in a competitive process. Twenty-three students and researchers have been introduced to the pre-accelerator programme and 2 researchers have been through the accelerator programme, with one winning the programme prize.

FLEXIBLE TALENT MOBILITY AWARDS

The Flexible Talent Mobility Award (FTMA) is a training grant funded by the BBSRC. NBIC received 5 waves of funding that supported 44 placements between industries and academics which led to in-depth industry understanding and research skills updates. Placements were, on average 3 months in duration and ranged from £10K to £15K in budget.

ICURE AND SETSQUARED

NBIC is working with ICURe and SETsquared to offer our researchers training and mentoring to bring research ideas and ability through commercialisation processes to the marketplace. May 2022 saw the launch of the Biofilms ICURe Sprint programme. Funded and delivered in conjunction with NBIC, six academic teams from across the UK have won the opportunity to establish whether there would be a commercial market for their research with up to £44k of funding. The first of its kind to champion the biofilm industry, it was an accelerated version of the well-established Innovate UK Innovation to Commercialisation of University Research (ICURe) programme. It has leveraged the ecosystem of businesses and investors from both NBIC and SETsquared's ecosystem to enable the teams to 'get out of the lab' and validate their commercially promising research over eight weeks. Further advancement of the current programme is being developed along with a new programme, to reflect the high demand for the training from within the biofilm community.

The NBIC Doctoral Training Centre

BRINGING TOGETHER RESEARCH, TRAINING, AND ENTREPRENEURSHIP

The NBIC Doctoral Training Centre in Biofilms Innovation, Technology and Engineering (BITE) was established in early 2019. It is a world-class integrated pipeline of interdisciplinary training, involving a partnership between the universities of Edinburgh, Liverpool, Nottingham and Southampton, alongside international institutes and industry partners. It is the UK's first graduate training centre to address the skills and knowledge gaps in the biofilm field. The first cohort of 12 students started in October 2019. A further cohort of 8 BITE students joined in 2020-2021. Subsequently NBIC awarded its first round of CTP2 studentships, resulting in an additional 8 PhD candidates in 2022. We are excited to add 12 PhD students to our centre in 2023 and an additional 10 in 2024.

The Doctoral Training Centre draws on over 70 academic supervisors from physical, mathematical, engineering, life and clinical sciences within the partner research institutions to provide a unique, multidisciplinary and inter-sectorial training experience to the next generation of research leaders, innovators and entrepreneurs, to deliver breakthrough science and technologies in this field. Graduates are supported to develop broad innovation horizons and seamlessly transition from research into technology and impact arenas. Entrepreneurship Bootcamps are also offered, with the most promising commercial projects progressed to the ICURe accelerator programme, part of SETsquared, which is currently rated as the world's best university business incubator. We also partner with Alderley Park and their Accelerator Programme, to provide bespoke entrepreneurial training to our students.

The Doctoral Training Centre provides a unique and diverse environment to students, with opportunities to network with experts in other disciplines, engage in peer-to-peer learning and participate in collaborative problem solving, as well as partake in student exchanges with international centres of excellence, attend summer schools, joint-nature conferences, and secondments and masterclasses showcasing frontier thinking.

By combining the expertise of four core universities, the Doctoral Training Centre provides the synergy, critical mass, and the breadth and depth required to deliver an ambitious training programme in biofilm science, engineering and technology.

AREAS OF SPECIALISMS

University of Edinburgh Soft and Active Matter Biological Physics; Complex Fluids and Rheology; HPC Modelling; Biofilms Architecture; Synthetic and Systems Biology.

University of Liverpool Functional Surfaces; Materials; Smart Nanotechnology; Plasma Engineering; Imaging; 'Omics and Bioinformatics; Microbiorefinery; Infection Control; Modelling for Healthcare.

University of Nottingham Quorum Sensing and Signalling; Molecular Recognition; Drug Discovery; Polymer Discovery; Biomedical Engineering; AMR; Modelling; Synthetic Biology; Advanced Microscopy.

University of Southampton Microbial Ecology and Evolution; AMR; Hybrid Biodevices; Nanoelectronic and Photonic Devices; Bioenergy.

NBIC-CTP EQUALITY, DIVERSITY AND INCLUSION STRATEGY

The NBIC-CTP Equality, Diversity and Inclusion action plan was highly praised by the BBSRC review panel as "excellent and should be showcased as an example of best practice". NBIC intends to share the action plan with partnering research organisations, especially the BITE programme partners, to promote accessibility of PhD candidates and protect their physical and mental wellbeing.

QUOTES FROM BITE PHD STUDENTS

> *"Being a part of the NBIC cohort was fantastic, it was a great way to meet other microbiology PhD students at a similar stage. It also provided many opportunities to attend summits and training events across the UK, which were both fun and educational, meeting people from different areas and angles of biofilm research."*

> *"The NBIC BITE Doctoral Training Centre has provided me with access to some excellent interdisciplinary training which has helped to broaden my understanding of biofilm research. Helping on the NBIC stand at New Scientist Live in London was also a really fun and memorable experience for me during my time in the BITE DTC which allowed me to improve my science communication and outreach skills."*

POLICY NOTICEBOARD

COMMITTEE HEARING

Policy

WHAT WE HAVE PLANNED

NBIC formulated a working group, comprising members of the Executive Management Team and the Operational Management Group, to pursue our strategic priority of progressing NBIC's influence in the public sphere. Since the start of Phase 2, this working group has combined efforts with the Public Engagement and Outreach Committee and is now called the 'Policy and Public Engagement Group'.

NBIC foresees fully exploiting our strength in biofilm research to advance its reputation both nationally and internationally. Fostering and facilitating science cooperation in the area of biofilms (e.g NBIC's role in the International Biofilms Standards Task Group alongside the US, Singapore and the EU) helps to promote a truly Global Britain.

To help our partners and collaborators better understand and navigate the policy-making landscape in the UK, we have created the **Policy Noticeboard** on the NBIC website. This is a great resource and provides a helpful starting point to get engaged in policy matters in the UK. The website links to free training provided by the Knowledge Exchange Unit of the UK Parliament, guides on how to write a policy brief, and further information regarding UK and Devolved Nations' policy-making processes. We also use this page to highlight upcoming events and opportunities.

One highlight of this policy engagement over the last year was an invitation to give oral evidence to the (then) Commons Science and Technology Committee as part of 'My Science Inquiry'. This inquiry invites proposals on what the Committee should investigate next and why, including what action is needed from the Government. Previous inquiries were held in 2017 and 2019 and gathered over 160 inquiry ideas. Six organisations were invited to give oral evidence in this round. NBIC's CEO, Professor Jo Slater-Jefferies, did so on NBIC's behalf on 19 October 2022. Although NBIC's pitch was not chosen for further investigation by the CSTC, a complementary pitch on bacteriophages has been taken forward. NBIC is heavily involved in the KTN Phage Innovation Network, where we have representation on the advisory panel.

The recording of the session can be found on the **UK Parliament website**.

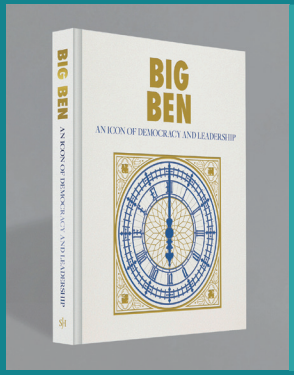
NBIC's CEO, Professor Jo Slater-Jefferies presenting to the UK Commons Science and Technology Committee.

NBIC is currently preparing policy statements and will soon invite the whole NBIC community to provide input and feedback on these policy statements:

- Standards and Regulatory
- Climate Change and Net Zero
- Educating Society on the Importance of Biofilms
- Biofilm and Microbiome

BIG BEN: AN ICON OF DEMOCRACY AND LEADERSHIP

NBIC has recently been profiled in association with the Houses of Parliament in a limited-edition publication of historical significance. **'Big Ben: An Icon of Democracy and Leadership'** is a new publication which explores the origins and history of Big Ben and the Palace of Westminster and celebrates the 180th anniversary and renovation of the famous clock tower. The book also highlights examples of achievement and progress across the social, cultural, political, technological and commercial spheres. NBIC are proud to be showcased in the 'Changing Times' chapter within the publication. An e-book version is available to download from the NBIC website.



BIG BEN: AN ICON OF DEMOCRACY AND LEADERSHIP

Communications and Outreach

RAISING AWARENESS OF BIOFILMS IN THE UK AND BEYOND

Public Engagement (dialoguing with the public about our research) and Outreach (raising science aspirations of the younger generation) in relation to biofilms are extremely important activities to maximise the impact of NBIC, and for society to gain an understanding of what biofilms are and how they relate to daily life. In particular, we want to reach the public with an active interest in biofilms related topics, such as home, hygiene and healthcare. We also strive to inspire the younger generation. NBIC has a Public Engagement and Outreach Officer in place to support members of the NBIC network in their engagement and outreach activities and we regularly develop appropriate resources for wider use to lead and inspire projects.

We have conducted a wide range of activities across the UK, which have included biofilm dances, biofilms in a train station, biofilm workshops at IKEA, the University of Southampton Science and Engineering Festivals and the 'Secret Lives of Biofilms' stand at both Science in the Park, the Festival of Science and Curiosity in Nottingham and the Royal Society Summer Exhibition in 2019 focusing on antibiofilm coatings (under the Prevent theme).

NBIC at New Scientist Live

In October 2022, NBIC participated at New Scientist Live, one of the biggest public science events in the UK. This was a great opportunity for NBIC researchers and PhD students to develop a public engagement activity related to their research, and gain experience from engaging with public audiences.

In July 2023, HRH The Princess Royal, opened a new building at the University of Edinburgh, the Nucleus, in which an art and physics exhibition showcasing NBIC's research on biofilms was displayed especially for the occasion. These artworks were created by students from the Edinburgh College of Art who discovered the research undertaken by NBIC's co-director Cait MacPhee and her group, especially around new coatings to prevent biofilms formation on boat hulls and the application of biofilms on ice cream properties. The exhibition featured biofilms-inspired embroideries made by illustration student and winner of NBIC's 2022 #BiofilmCreate art competition, Ruby Tait. The exhibition will remain on display and open to the public for the foreseeable future.

Moving forwards we will use our #BiofilmAware campaign together with new and existing resources to support a greater number of NBIC partners to deliver public engagement activities to a wider audience, covering much of the UK and with a focus on rural and non-metropolitan regions. We will also be working on a project to develop a repository of downloadable resources to improve accessibility and user experience for researchers and the public.

#BIOFILMAWARE

#BIOFILMWEEK

In August 2020, we launched our biofilm awareness campaign. Through a blend of content, events and outreach activities #BiofilmAware works to raise awareness of NBIC and its research, and the societal and economic impacts of biofilms.

As part of the campaign, our annual #BiofilmWeek takes place in line with World AMR Awareness Week each year from 18-24 November across social media to further promote the impact that biofilms have on our world, as well as highlight research taking place to prevent, detect, manage and engineer biofilms.

In 2022, the engagement with the awareness week was high, and content from participants across the world included news articles, video content, photography and art. The hashtag '#BiofilmWeek' was used 280 times during this time. Throughout the week, we highlighted interesting and exciting biofilm research being undertaken across our partner institutions. This ever-growing **'Research in Focus' series** now features 19 video interviews and blogs with early career researchers, PhD students and our Interdisciplinary Research Fellows.

A dedicated #BiofilmWeek webpage features NBIC owned tools and resources to support scientists in industry and academia to create their own content in order to showcase their research and technologies. Interaction with the webpage is ongoing and has been viewed 3,400 times.

'RESEARCH IN FOCUS' SERIES

#BiofilmCreate Photography and Art Competition

2022 WINNERS

Our annual #BiofilmCreate competition is a great opportunity for members of the public, budding artists and photographers to explore biofilms in their everyday environments and is also a chance for scientists to look at creative ways of showcasing their cutting-edge research.

Our **Biofilm Image Gallery** and **Biofilm Art Gallery** contain a selection of photography and art from our #BiofilmCreate competitions.

BIOFILM IMAGE GALLERY

BIOFILM ART GALLERY

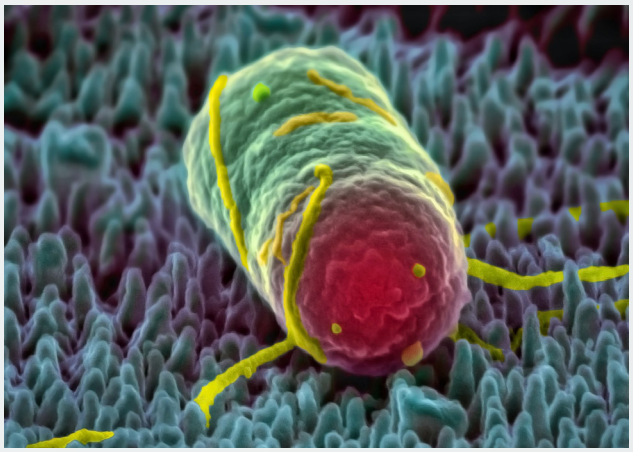
ART

1ST PLACE

Ruby Tait, University of Edinburgh

BIOFILMS IN DEPTH

Embroidered pieces depicting the range of biofilms research. The four embroidery hoops are inspired by the study of the movement of biofilms, the study of individual biofilms, the use in everyday products.



2ND PLACE

Irill Ishak, University of Bristol

THE DYING FACE OF *E. COLI*

A seemingly dying *E. coli* cell lying on top of a polyethylene terephthalate (PET) nanospiked surface after incubated for 3 hours. The image was acquired using FEG-SEM at 75-degree tilt angle and magnified at 100000x magnification which revealed 'the dying face of *E. coli*' where the 'eyes' and 'mouth' are the cell's surface proteins while the flagella as the 'arm' of the cell. Irill Ishak's research suggests that this particular bacterium is dying due to the interaction with the nanospikes. The nanospikes are stretching and rupturing the cell membrane which causes the bacterium unable to proliferate and eventually died, thus limiting the chances of biofilm formation. This image was acquired at Wolfson Bioimaging Facility. The backscattered and secondary electron micrographs were acquired, false coloured in Adobe Photoshop, and combined to get the final image.

3RD PLACE

Sam Church, Emma Roe, Sandra Wilks and Paul Hurley, University of Southampton

MICROBIAL NEIGHBOURING

Set of illustrations by Sam Church that narrate conversations in a workshop run by Emma Roe and Paul Hurley on Microbial Neighbouring, with members of the Global Network for Anti-Microbial Resistance and Infection Prevention (Global-NAMRIP).

DOWNLOAD SET OF MICROBIAL NEIGHBOURING ILLUSTRATIONS

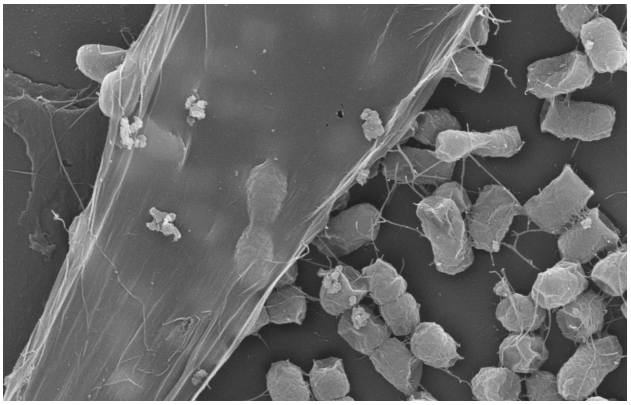
PHOTOGRAPHY

1ST PLACE

Mark Burton, University of Southampton

OXIDISED GOO

In this stagnant pond, bacteria oxidises the iron released from the ground water creating this bright orange slime.

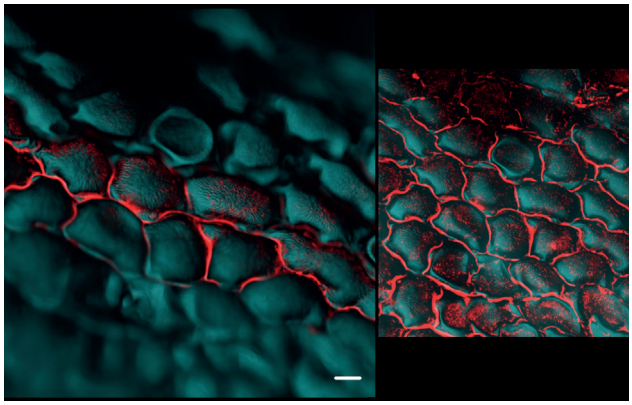


2ND PLACE

Jiaqi Luo, University of Liverpool

BIOFILM

It is really a 'film!' Don't just look at it but feel it! Feel the smooth texture at the centre of the EPS, feel its subtle interaction with the curli expressed by the *E. coli* on the edge. It was also a beautiful mistake how this 'film' was obtained, simply a tilted substrate, and the medium-air interface plays the magic.



3RD PLACE

Manuel Romero, University of Nottingham

BIOFILM ERUPTION

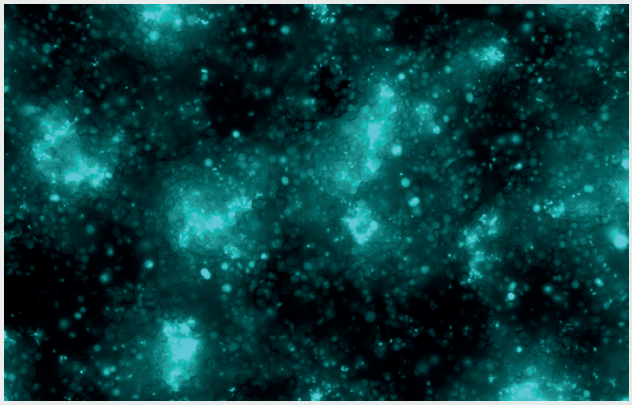
Bacteria (red) colonising the surface of a Hortensia petal replicate (cyan). Bio-mimicking fabrication methods are explored to create nano and micro-structured surfaces with antibiofilm properties for medical implants. Natural surface architectures reveal an exciting variety in surface topography. On the Hortense surfaces, red fluorescent bacteria attached mainly on the grooves next to the micrometer size folds displaying a magma-like flow outpouring volcanic mountains. Scale bar 20 μm.

COMPETITION ORGANISERS PICKS

ART: Ian Golding, University of Southampton

PETRI CONSTELLATION

This is a small sculptural form that imagines the possible contents of a petri dish as imaginary planets in an ancient constellation map.



PHOTOGRAPHY: Evan Wroe, Joshua Lawrence and Mairi Eyres, University of Cambridge

SYNECHOCYSTIS LIT FROM BEHIND

A fluorescent flavin (cyan) has been added to the cyanobacteria *Synechocystis* (also known as blue-green algae), to help image the electrochemical gradient across the *Synechocystis* biofilm. Unfortunately, it is mostly sucked up by the extracellular matrix that the cells produce to form a biofilm. At this resolution, and lit from behind by the flavin, it reveals the cells as little bubbles of liquid.

2022 JUDGING PANEL

Our diverse panel of **5 judges** took part in an unbiased and anonymous judging process.

We sincerely thank the judging panel for their time and efforts in supporting our competition.

Chris Denning: Director of the University of Nottingham's Biodiscovery Institute.

Paul Maguire: Freelance Photographer, with a background in Earth science and exploration.

Neil Parry: R&D Programme Director of Biotechnology and Biosourcing at Unilever and NBIC Industrial Advisory Board member.

Tim Self: Head of School of Life Sciences Imaging (SLIM) from the University of Nottingham.

Catriona Clark: Art student from the University of Edinburgh.

Our 2023 competition is now open and will run until 20 October 2023.

Visit the **competition webpage** to submit your entries.

BIOFILM CREATE COMPETITION WEBPAGE

Case Study

RAMAN AGAINST RESPIRATORY INFECTION

Helping to support biofilm models to assess novel interventions

Diagnosing a bacterial infection and determining the best treatment for it is typically a slow process, taking days, while successful clinical outcomes often depend on rapid prescription with effective antibiotics. This promotes the use of broad-spectrum or unnecessary antibiotics, which in turn contributes to the rise of antimicrobial resistance (AMR).

Dr Callum Highmore and his team at the University of Southampton have been investigating a rapid alternative to conventional infection diagnostics called Raman spectroscopy. The group have used this technique to characterise bacterial pathogens at the strain level and are now applying it to identify phenotypic information such as AMR profiles.

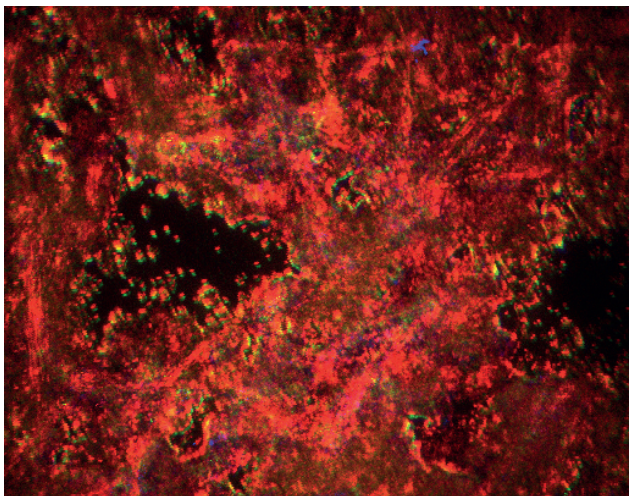
The team have developed and patented a new methodology for improved identification of bacteria called MX-Raman, and Dr Highmore has recently been awarded a Bridging Fellowship to transition from using pure bacterial cultures to examining clinical sputum samples using MX-Raman. This chapter of the project will be completed in summer 2024.

The outcome of this work will significantly benefit the public through rapid diagnosis of infection and treatment recommendations, reducing the burden of bed space on the NHS, improving clinical outcomes, and slowing the global development of AMR. Dr Highmore said,

“Being an NBIC-funded research fellow has really helped with both my professional development and with the progression of my research. We received some NBIC seed funding money, which has helped us open up a new dimension for this project, where we can use Raman imaging to start to interrogate how biofilms sit together and interact without the use of labels. This will give us some important data for future fundamental studies into biofilms, particularly regarding how different species take prominence in infection and what that might mean for patients”

“NBIC has also offered a valuable framework for me to work with companies on several different projects, which pays for my time so I can work on this main Raman project for longer”.

The team are currently working to translate their work towards the clinic, by investigating clinical samples and building large data libraries to build predictive models for diagnosis. In the longer term, this will require greater input from engineers and computer scientists as they work towards a prototype commercial product.



Coherent anti-Stokes Raman spectroscopy (CARS) label-free image of a PAO1 biofilm, false colour. Excitation at 797 nm indicates the presence of lipids (red), protein (green), and DNA (blue). Image by Dr Callum Highmore.

Dr Callum Highmore

Dr Highmore is an NBIC Interdisciplinary Research Fellow at the University of Southampton investigating rapid and reagentless detection methods for pathogens and biofilms. His main research focus is developing Raman spectroscopy into a clinical diagnostic tool.

Case Study

A PARADIGM SHIFT IN THE APPLICATION OF BIOINPUTS

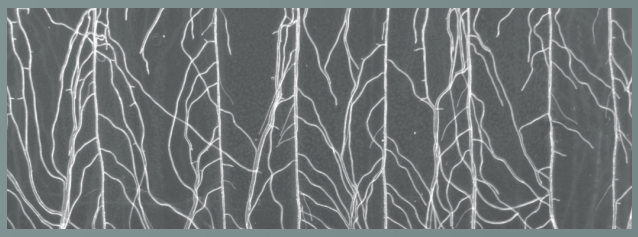
Supporting academic and industrial partnerships to tackle global biofilm problems

The extensive use of chemical fertilisers and pesticides has facilitated the expansion of agricultural practices as a solution to global food supply. However, their excessive and prolonged application has led to detrimental effects such as soil degradation, water contamination, and the detection of residues in food.

Plant growth-promoting bacteria (PGPB) represent a widely adopted approach globally to enhance plant growth and productivity. North America has the largest market of biofertiliser, meanwhile, South America hosts the fastest growing market.

In October 2022, NBIC, in collaboration with a group of Argentine researchers organised a workshop, within the framework of the annual congress of the Argentine Society for General Microbiology (SAMIGE), focused on biofilms in agriculture, which took place in Los Cocos, Córdoba, Argentina. The workshop brought together researchers and industry representatives from the UK and Argentina, to improve agricultural productivity in both countries by reducing the use of chemical treatments and their environmental impact.

As a result of the workshop, University of Nottingham attendee, Dr Gabriel Castrillo, applied for NBIC's Flexible Talent Mobility Account (FTMA) and was awarded funding for a research project to analyse the impact of the root microbiome biofilm on the beneficial effect of *Azospirillum* bacteria on crops. Understanding this type of interaction is extremely important to optimise the application of inoculants. Based on the hypothesis that the ability of an inoculant to colonise the plant and exert an effect can be modified by the presence or absence of member of the plant and soil microbial communities, a model experiment was designed. The impact of the different inoculant combinations on root growth was established and



Examples of the root system of the model plant Arabidopsis thaliana inoculated with a beneficial bacterium. Image by Dr Gabriel Castrillo.

samples prepared for more in-depth analysis following the FTMA award. Dr Castrillo said:

"In addition to scientific goals, the project also aims to establish a collaborative relationship between Argentina and the UK, with the objective of fostering scientific cooperation".

This objective was successfully achieved through the training of a postdoctoral fellow, who received the necessary expertise to conduct experiments relevant to the project. This collaborative effort has facilitated the joint work of laboratories from both countries, promoting knowledge exchange and cooperation in the scientific community.

The results obtained so far could serve as the basis for initiating a paradigm shift in the application of bioinputs on a global level. They represent one of the first steps in understanding the interaction between exogenously added inoculants and the established microorganisms in the plant tissue. Although these results come from a basic experimental model, further progress in this field will enable the development of biotechnological tools that will have an impact on both bioinput production and the companies involved, as well as their application in the productive sector. Moreover, advancements in the field of biological inoculants will also have a positive environmental impact by promoting the use of eco-friendly products.

Dr Gabriel Castrillo

Dr Castrillo studied biochemistry at Havana University, Cuba. His PhD focused on phosphate starvation response signalling at the Spanish National Centre for Biotechnology. He conducted a Postdoc there, unravelling arsenate signalling in plants. Later, he pursued a second Postdoc at the University of North Carolina, studying plant microbiome interactions. In 2018, he was awarded a University of Nottingham Research Fellowship, and continues his work there as an Associate Professor.

Case Study

NATURE VS AMR

Supporting the next generation of scientific leaders

Multi-Drug-Resistance bacterial infections pose a serious threat to global health due to increasing bacterial resistance against currently used antibiotics and the lack of new classes of antibiotics to combat resistant bacterial pathogens. In 2019, nearly five million people lost their lives due to antibiotic resistance-associated infections and millions more live with poor quality of life due to treatment failures.

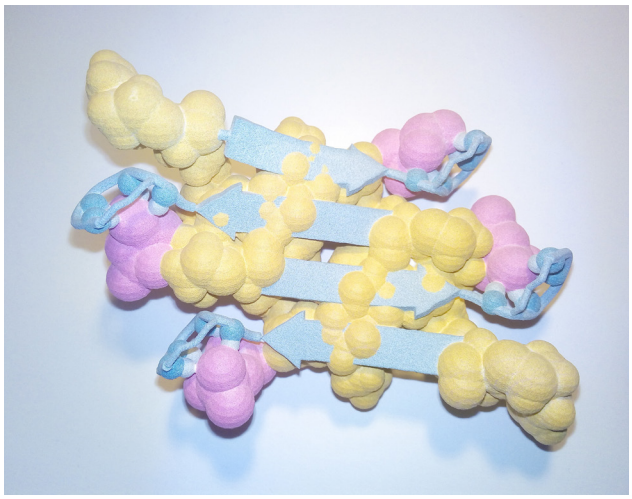
Currently, most antibiotics used or under development for treatment suffer from resistance issues leading to treatment failure. Moreover, the development pipeline of innovative antimicrobials is nearly dry. Together with their research group at the University of Liverpool, Dr Anish Parmar and Dr Ishwar Singh "aspire to bring new hope to improve and save lives currently lost due to AMR". They aim to achieve this by refreshing the antimicrobial pipeline with innovative molecules.

Natural products are usually complex molecules. The team simplify these molecules to develop a library of simpler molecules and use this process to select desirable drug-like qualities to maximise their therapeutic potential, an important aspect of drug development. The team have applied this process to a natural antibiotic, teixobactin, to address its developmental challenges, such as safety and scalability. This has successfully treated MRSA infections in several *in vivo* preclinical models and the team are now moving this forward in preclinical testing. and hope to treat patients in the clinic within five years.

Dr Parmar recently participated in the NBIC-funded SETsquared Biofilms ICURe Sprint, seeking market validation for their technology. The project received positive feedback during the options roundabout panel, leading to a successful pitch. The panel recommended advancing with a spinout and pursuing Innovate UK follow-on funding. During the ICURe stage, the focus was to understand and undertake market validation for the product and also map the Intellectual Property landscape to ensure a robust pitch to attract investment. This was achieved, as the team received strong interest from multiple stakeholders, including investors. Dr Parmar said,

"NBIC offered valuable advice and helped us identify the most appropriate pathway to pursue. The extensive network available through NBIC facilitated effective outreach and connections".

The team have now secured follow-on funding from Innovate UK to establish a spinout. At present, they are on the verge of spinning out and actively pursuing further funding and collaboration opportunities.



Mechanism of action of antibiotic forming antiparallel β-sheets (blue) bound to bacterial Lipid II (yellow and pink). Image courtesy of Professor Markus Weingarth.

Dr Anish Parmar

Early Career, University of Liverpool, researcher and PDRA with 10 years expertise in synthetic peptides and 8 years with antimicrobial teixobactins. Received the sole award "Excellency in research" for the work done on Teixobactin.

Dr Ishwar Singh

Reader in Antimicrobial Drug Discovery and Development at the Departments of Pharmacology and Chemistry, University of Liverpool. He has 24 years of experience in Medicinal Chemistry, focusing on drug design and development and antimicrobials.

Case Study

USING SYNTHETIC MATERIALS TO MODEL MARINE BIOFILMS

Supporting the next generation of scientific leaders

Marine biofilms can cause up to an 11% increase in ship shaft power which has environmental and economic consequences. As biofilms are heterogeneous and adaptable, rigid models are often used as a benchmark for studying biofilm associated drag; however, these models neglect natural biofilm behaviour, such as viscoelasticity which could lead to under-estimations in drag penalty. Understanding how biofilms properties interact with one another and with fluid flow, and how these interactions influence drag can further research on strategies for managing and preventing biofilm presence can be used to inform the shipping industry of more efficient biofilm targets.

An NBIC-funded Proof of Concept (POC) project between the University of Southampton and AkzoNobel investigated the use of synthetic materials to model marine biofilms. Alexandra Snowdon was part of the AkzoNobel team working on the POC. She then went on to study as an NBIC BITE student, with the results of the POC project forming the basis of her PhD.

Her research focused on marine biofilm physico-mechanics and the effects these have on ship-drag using artificial and real-life systems. By using imaging techniques in conjunction with a flow cell the group were able to capture biofilm physico-mechanical properties in-situ in real time whilst measuring drag. It was concluded that marine biofilms are viscoelastic, that viscoelasticity plays a significant role in drag production and that it shares complex interactions with biofilm structure.

It was also shown that an elastomeric sandpaper model system produced up to a 52% increase in drag when compared to rigid counterparts; the model also simulated drag curves and relationships between physico-mechanical properties like that observed for naturally grown marine biofilms. As a result, it is believed that the synthetic system proposed is a more appropriate substitute for modelling viscoelastic biofilms and highlights how systems that only capture rigid roughness could be underestimating drag.

Microscope image taken of a marine biofilm grown on a static circular coupon (4 cm dia.) in Hartlepool Marina. Algal components can be seen in red, diatom chains in orange and to the bottom right an animal can be seen. Image by Alexandra Snowdon.

Alexandra has recently completed her PhD and two academic papers have already been published and acted as milestones for the project. The first was on developing the artificial biofilm system to demonstrate how softer and deformable materials could better mimic marine biofilm properties than rigid ones; the second was on studying the rheological properties of marine biofilms to demonstrate marine biofilm viscoelasticity and the relationship this has with structure. Dr Jennifer Longyear from AkzoNobel said,

“Alex’s work forms a strong foundation for expanded quantitative analysis of the contribution of biofilm mechanics to marine biofilm fouling hydrodynamic drag properties. Her work is an exciting development as this research topic is challenging to approach experimentally. We have adopted Alex’s methodologies and anticipate future work will lead to further insight regarding ship slime drag”.

Since completing her PhD, Alexandra has started working as a Statistical Data Scientist at the Office for National Statistics.

Alexandra Snowdon

Alexandra Snowdon has recently completed an industrial-sponsored PhD with the University of Southampton and AkzoNobel. Her research involved studying marine biofilm physico-mechanics and the effects these have on ship-drag using artificial and real-life systems. Alexandra’s supervisors from the University of Southampton were Paul Stoodley, Julian Wharton and Simon Dennington and from AkzoNobel, Jennifer Longyear.

Case Study

INNOVATIONS IN WASTEWATER TREATMENT

Assisting the academic community to find the right industrial partner

The Wastewater treatment (WWT) market is estimated to be worth over $300bn worldwide, yet globally 44% of municipal wastewater is not treated safely, with up to 2.3bn people not having access to basic sanitation. Recent news reports about sewage release into the UK's waterways have highlighted several grand challenges associated with this process. Researchers at the University of Edinburgh, in collaboration with Veolia UK, have been investigating three strands of research helping to address this. Dr Gavin Melaugh, Professor Cait MacPhee, Dr Efthalia Chatzisymeon, Dr Ryan Morris and PhD students Anne-Maelle Penot and Holly Bridge are working on these projects in collaboration with Paul Banfield, Technical Operations Manager at Veolia UK.

Understanding how filamentous cells impact flocculation in activated sludge (AS)

In collaboration with Veolia and ETH Zurich, researchers have performed a systematic study on the activated sludge bacteria *Comamonas denitrificans* to understand how bacterial cell length impacts connectivity in aggregating suspensions of cells. This work was initiated by an NBIC Proof of Concept award and the team now have a new PhD student (Holly Bridge) developing the research further through agent-based modelling.

Developing the Sludge Characterisation Platform (SCP)

There has been little modernisation in WWT over the last 100 years. For example, in this era of sophisticated software, e.g., AI, sludge health is still assessed by periodic visualisation of WWT samples under the microscope and relies heavily on the expertise of the operator. In collaboration with Veolia, Dr Melaugh and his team were awarded an Impact Acceleration Award (IAA) to develop the Sludge Characterisation Platform (SCP); a machine learning tool for AS health.

In the 9-month IAA, the team successfully trained the SCP using the library of images provided by Veolia, and after optimising the parameters, the SCP was then used to assess unseen microscopy images of the sludge as either "healthy" or "unhealthy" with an accuracy of up to 85%. They are currently exploring funding options to develop this technology further.

Understanding the microbial generation of nitrous oxide in WWT

Nitrous oxide (N_2O) is generated as a microbial metabolic by-product in nitrogen-removal processes in WWT. It is ~300 times more potent than CO_2 and is the main contributor to ozone depletion. As a result of regulatory pressure, there is now a need for WWT companies to develop methods to detect N_2O, as well as understand how the microbes can be manipulated in order to reduce its release into the atmosphere. As a result, Veolia have sponsored a PhD studentship (Anne-Maelle Penot) in collaboration with the School of Physics and Astronomy and the School of Engineering at the University of Edinburgh in order to develop an understanding of N_2O-generating bacteria in WWT.

Dr Gavin Melaugh said,

"The initial funding from the NBIC Proof of Concept award was crucial in seeding the team's now long-term collaboration with Veolia UK".

Foam forming on the aeration tank in Veolia's Newbridge WWT facility. The foam is caused by the proliferation of filamentous organisms.

Dr Gavin Melaugh

Dr Gavin Melaugh is a Chancellor's Fellow at the University of Edinburgh, joint appointed between the School of Physics and Astronomy and the School of Engineering. He leads a group that uses a combination of experiments, microscopy, and computer simulations to understand the collective behaviour of microorganisms in the natural environment and in biotechnological processes. Dr Melaugh has been a core team member of NBIC since its formation in 2017.

Case Study

IMPROVING PATIENTS' QUALITY OF LIFE

Helping industry find academic partners to solve unmet needs

According to the World Health Organization, each year, an estimated 4% of people with long-term urinary catheters will develop a CAUTI or blockage. Bacteria can enter the bladder during catheter insertion, through the catheter lumen and along the catheter urethral interface. Infection and blockage risks rise the longer a catheter remains in place, because the bladder and catheter become colonised with bacteria, which cannot easily be removed. The presence of a urinary catheter enables bacteria to form a biofilm, which creates a sticky, slimy, and sometimes crystalline, layer that protects bacteria from both antimicrobials and the person's natural immune response. When a bladder fills and empties normally, bacteria are flushed away; this protection is lost when a person has a urinary catheter on continuous drainage.

Catheter-related problems cause distress for patients, reduce quality of life, and create unplanned expenditure for the health service and families. Finding a solution that reduces adverse effects caused by catheters will result in significant benefits to the health service, social and voluntary services and the families who care for these patients.

NBIC Proof of Concept funding supported a collaboration between University of Southampton researchers Dr Sandra Wilks and Professor Mandy Fader and medical device company, NanoVibronix.

The project shows the effect of the UroShield™ CE-marked device on bacterial populations in patients with indwelling urinary catheters. An evaluation was conducted to assess any changes to the catheter-associated microbiome in order to understand the impact of the UroShield™ on the biofilm community. Patients were also interviewed to understand the impact of using the device on quality of life.

UroShield™ is a low-energy, battery powered device with an accessory designed for application to the extracorporeal segment of all types of urological (urethral or suprapubic) catheters and is intended to minimise bacterial adhesion and colonisation on the catheter surfaces.

The Nanovibronix UroShield™ is applied externally to the catheter and has been developed to prevent catheter blockages and biofilm contamination, resulting in a reduction in urinary infections, improved patient outcomes and lower healthcare costs. The UroShield™ utilises low-frequency ultrasonic acoustic waves (Surface Acoustic Wave) which run longitudinally along both the inner and outer surfaces of the catheter. These surface acoustic waves prevent bacteria from docking and adhering to the catheter and subsequently prevent the formation of biofilm. Initial results of the independent, real world patient study suggest changes in the microbial population diversity following use of the UroShield™, with potential beneficial effects on the urinary and catheter microbiome. A further study focused on the bladder microbiome and beneficial effects through the use of ultrasound may lead to the generation of additional Intellectual Property.

As a result of the project, the company were able to extend their aims to include more patient reported outcomes and now have a data set with microbiological data and information on device use and acceptability. Brian Murphy, Chief Executive Officer at NanoVibronix Inc. said,

"We are continuing our collaboration with the teams at the University of Southampton and applications are being developed to allow for a full randomised control trial. The microbiological results have been very interesting and we would be keen to explore opportunities to understand the mechanisms of action in more detail and to enable us to continue working with the Dr Wilks' team at Southampton".

Dr Sandra Wilks

Sandra Wilks is an Associate Professor in Applied Microbiology at the University of Southampton. Her interests are in understanding biofilm communities and she has worked across several areas, including drinking water, built environment, food safety, and medical device management.

Brian Murphy

Brian Murphy is Chief Executive Officer of NanoVibronix Inc., a medical device company focused on creating medical products utilizing its proprietary low-intensity, surface acoustic wave technology. The company's patented technology allows for creation of miniature transducers that transmit low-frequency, low-intensity ultrasound through flexible material surfaces. This unique platform is being utilised for a variety of medical applications.

Case Study

RAPID SUSTAINABLE DIAGNOSTICS

Supporting researchers to tackle global issues associated with biofilms

Loughborough University based biotechnology start-up, Cromerix, is working to tackle the growing global issues in healthcare, industry and home, due to microbial infections and contaminations, which have an economic impact of $5 trillion per annum associated with biofilms, and an estimated annual burden of >$1 trillion by 2050 for antimicrobial resistance. The start-up currently specialises in aptamer-based products that can deliver rapid sustainable diagnostic solutions, which has a global market size of ~$5 billion. These aptamer-based techniques are transferrable to engineering biology applications that have an estimated global economic impact of $4 trillion in the next 10-20 years. Dr Sourav Ghosh, Director at Cromerix and Senior Lecturer at Loughborough University, said,

"We received an NBIC Flexible Talent Mobility Award (FTMA) worth £20k, which was crucial in piloting research activities and intellectual property build-up".

The initial concepts developed from this project supported the win of a Fast Start Innovate UK grant worth £50k, which further helped in proving the feasibility of Cromerix's single-step microbial detection technology. The growing technology evidence also helped the start-up win industry funding in fuel contamination measurement. Additionally, NBIC extended vital help in connecting with potential customers, some of whom are continuing to engage with Cromerix around funding future development against a possible licensing agreement.

Cromerix's diagnostic programme can deliver the world's fastest definitive microbial test that informs both infection/contamination and antimicrobial selection. This is the first specific test having a broad microbial coverage, but can be designed to be species-specific where needed. The intrinsic speed, ease of use, and low cost and carbon footprint of the test promises its sustainability and adoptability widely across clinical and non-clinical sectors for early diagnosis and intervention, transforming care/product quality and costs.

Cromerix has demonstrated rapid broad bacterial detection (gram-negative and gram-positive) and antibiotic sensitivity testing using a single-step aptamer-based fluorescence-switch assay. It has also designed concepts for microbial viability detection, equipment-free colorimetric detection, and a method and aptamer for engineering a human microbiome-specific bacterial metabolic activity. The start-up has engaged customer interests in the fields of wound infection diagnostics, and contamination in fuel, and pharmaceutical and personal care products manufacturing sectors. Their findings on diagnostic and engineering biology programmes have significant potential impact across a broad range of clinical and non-clinical sectors, including industry, home, defence, space, and environment.

With support from Alderley Park, the Innovate UK Microbials Accelerators, and Innovate UK Edge, Cromerix is working with experts to build an IP and regulatory strategy.

To support the core technology development and application-specific validations, Cromerix is actively seeking grant, industry and private funding, industry and clinical collaborators and commercial advisors in the space of microbial diagnostics (clinical and non-clinical), antimicrobial resistance, microbiome, and engineering biology.

Aptamer – a uniquely folded short single-stranded DNA/RNA at the heart of Cromerix's technology (an artistic view).

Dr Sourav Ghosh

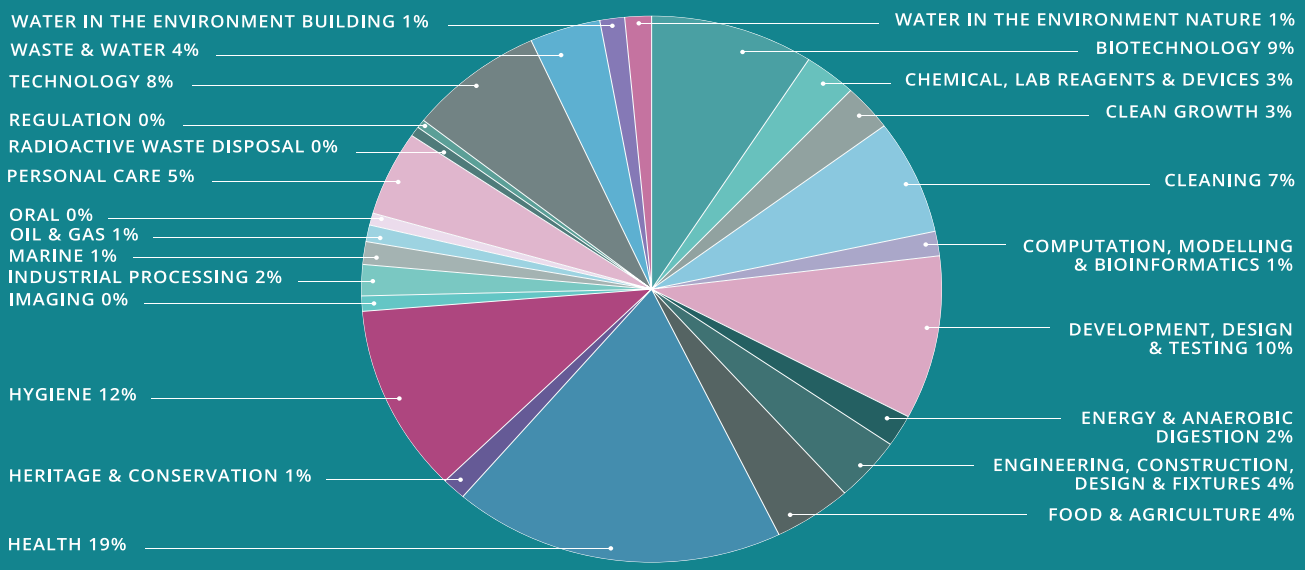
Dr Sourav Ghosh is a Senior Lecturer at Loughborough University, leading biosensors research for over 10 years. He has supervised 8 PhDs and 5 postdocs, and won UK/EU research and enterprise grants worth over £2m. He post-graduated in biomedical engineering from the University of Oxford and studied for his PhD and postdoc at the University of Cambridge. Currently, he is delivering impact from his biotechnology research as the Director of Cromerix, a start-up based at Loughborough University.

Proof of Concept Projects

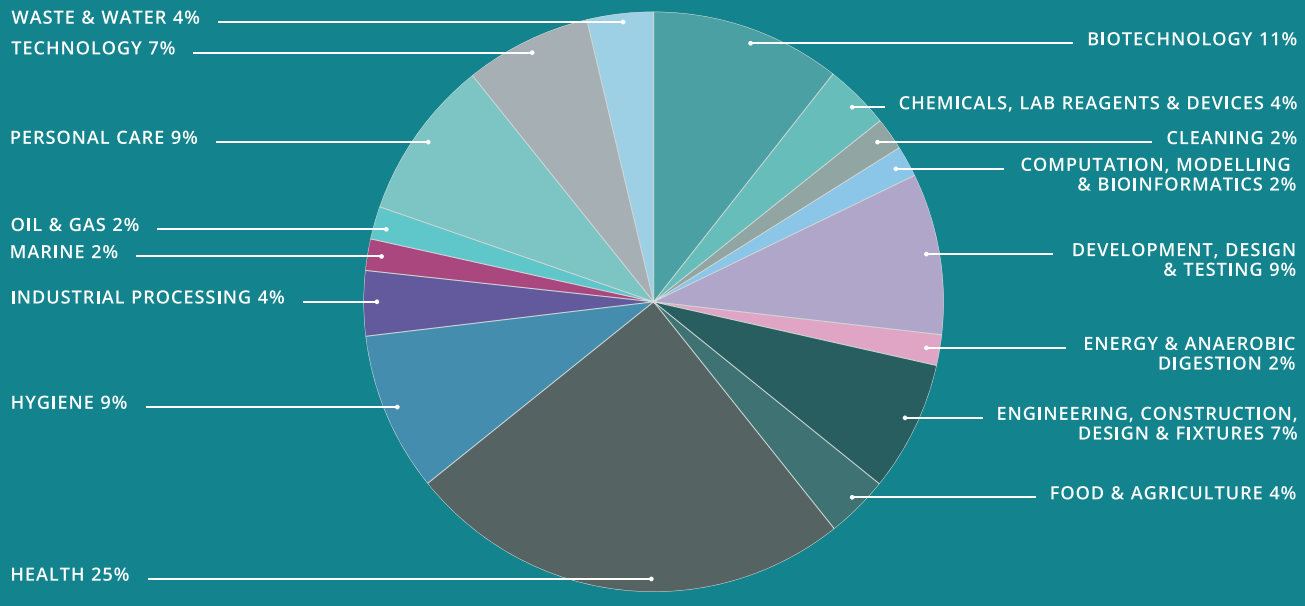
SUPPORTING TRANSLATIONAL ACTIVITY

Our investment in biofilm innovation

To date, we have run 4 Proof of Concept (POC) calls attracting 207 applications from which we awarded funding to 83 projects. This represents an investment of £4.4m from NBIC and £6.7m total value when we also consider funds from companies either in cash or in kind. These applications have involved 39 research institutions, 140 companies - and of these companies more than 50 are SMEs. These applications have shown a spread across our 4 key interventional themes, with each successive call showing a more even balance as our outreach takes effect. In addition, we have seen engagement from a diverse set of industrial sectors demonstrating the broad impact of biofilms.



POC4 Applications by sector



POC4 Awarded by sector

Proof of Concept 1

AWARDED OCTOBER 2018

PROJECT TITLE	PROJECT SUMMARY	UNIVERSITY/ RESEARCH INSTITUTION	COLLABORATOR/S
Managing aquatic biofilms via surface manipulation	Biofilms within distribution pipes present a major risk to drinking water safety. In marine environments, coatings have successfully altered surfaces to mitigate biofilm risks. This project explores the novel application of marine-coatings to drinking water pipes to prevent/ limit and manage biofilms by comparing biofilm behaviour using innovative analytical techniques.	University of Sheffield	International Paint Ltd (AkzoNobel) and Dŵr Cymru Welsh Water (DCWW)
Accelerating antisense PMOs to the clinic	We plan to hijack a mechanism used by bacterial pathogens to uptake essential nutrients, to deliver synthetic RNA fragments which can switch off the expression of specific genes required for survival and kill these pathogens in a biofilm. This innovative technology could potentially have a strong impact in combating AMR.	University of Nottingham	Belfry Therapeutics
A model oral system for oral healthcare risk assessment	Hundreds of microorganisms live in the mouth, many are harmless while others cause caries and gum disease. This project will utilise an *in vitro* model system to investigate how oral hygiene products may affect this complex oral microbiome to better predict product efficacy.	University of Southampton	Unilever Safety and Environmental Assurance Centre (SEAC)
PlasmaHeal: cold plasma to control biofilms in wound dressings and at the wound/dressing interface	Biofilms are a major problem in non-healing and infected chronic wounds due to their recalcitrance to immune clearance and antimicrobial agents. Cold plasma technology is highly effective against biofilm contamination. This project will bring together expertise in biofilms, wound care and plasma to develop a novel 'plasma activated wound dressing'.	University of Liverpool	5D Health Protection Group Ltd
BIOFILMer: a super-resolution platform for the analysis of crystalline biofilms in urological devices	Urological devices are widely used in the clinic to treat kidney stones, tumours, and incontinence. They however suffer from biofilm formation, causing severe side effects. In this project, we will establish the first platform for super-resolution analysis of biofilms in urological devices, enabling development of safer and biofilm-resistant treatments.	University of Southampton	Oxford Nanoimaging Ltd (ONI) and Center for Biofilm Engineering (CBE), Montana State University
Development of a Moving Membrane Bioreactor (MMBR) for the automated cultivation and harvest of algae grown as a biofilm	Many microalgal species are grown commercially to produce a range of sustainable bioproducts, with further product diversification hindered by high production costs. This consortia has developed a membrane based technology to cultivate algae as a biofilm, reducing production costs and opening the possibility to cultivate novel high value strains.	Plymouth Marine Laboratory	Varicon Aqua
Development and evaluation of a dual function dressing to combat biofilm infection and exudate in chronic wounds	Dressings have been designed to separately address problems associated with chronic wounds including exudate (wound fluid) and biofilms (microorganisms growing on surfaces that are highly tolerant to antimicrobials). This project will assess the anti-biofilm efficacy of a newly developed wound dressing capable of absorbing high levels of exudate.	University of Manchester	Systagenix Wound Management and 3M
The effect of low frequency ultrasound on urinary catheter biofilms: a crossover study	Finding ways to reduce infections caused by catheters (tubes) in the bladder is a top priority in the NHS. We have evidence that an ultrasound device (Uroshield) that clips onto catheters could prevent infections. In this study we will use proven methods to find out if it really works.	University of Southampton	Nanovibronix Inc (Ideal Medical Solutions UK)

PROJECT TITLE	PROJECT SUMMARY	UNIVERSITY/ RESEARCH INSTITUTION	COLLABORATOR/S
New generation colour-encoded coatings for surgical tools with intrinsic antimicrobial action	This project optimises technology to produce intrinsically antimicrobial coatings for surgical tools. This addresses an important NHS-identified need for self-cleaning surfaces, combined with distinct colour and lustre required for end-user compliance within surgical theatres. Detailed surface chemistry and biological testing will accelerate commercialisation of existing IP.	University of Liverpool	Gencoa Ltd
Measuring biofilm formation in venous catheters	The placement of catheters into a patient's veins is widespread in hospitals, but poses a serious infection risk due to biofilm formation. We will measure biofilm formation on a range of catheters provided by Kimal Plc, to determine how catheter design can be improved to reduce the risk of biofilm formation.	University of Edinburgh	Kimal Plc
Corneal biofilm models and anti-biofilm nanoparticles	Bacterial and fungal keratitis is a major problem in many low/middle-income countries (LMIC). There is a need for stable and affordable treatments that can control diverse eye infections. Antimicrobial nanoparticle formulations can provide the antimicrobial and physical properties needed to destroy biofilm structures without damage to sensitive eye tissue.	University of Sheffield	Tecrea Ltd and Blueberry Therapeutics
Low dose nitric oxide for the effective treatment of chronic wounds	Wounds that don't heal are associated with bacteria in communities known as biofilms which are resistant to antibiotics. We have shown that low dose nitric oxide can help disperse lung biofilms win patients with cystic fibrosis. This project will test whether nitric oxide can also disperse biofilms from infected wounds.	University of Southampton	Smith+Nephew Ltd
Blue light treatment of *Listeria* under environmental conditions	*Listeria monocytogenes* is an important foodborne pathogen, causing recent fatal outbreaks across Europe and South Africa. *Listeria* can persist in food factories in biofilms despite sanitising procedures. Blue light (~405 nm) could be an additional operator-safe disinfection measure, however its impact against *Listeria* in factory conditions is unknown.	Quadram Institute	Chilled Food Association
Evaluating an innovative plasma (fourth state of matter) technology for prevention and management of biofilms in the food industry	In the food industry, increased resistance of biofilm-forming bacteria such as *Listeria* has led to a need for new approaches for decontamination of food and food processing surfaces. This project will evaluate an innovative plasma (fourth state of matter) technology for biofilm prevention and management on food and hard surfaces.	University of Surrey	Fourth State Medicine Ltd
A novel laboratory biofilm model to accelerate the commercialisation of anti-biofilm products for the benefit of patients with chronic wounds	Organisation of bacteria as communities called biofilms in wounds delays healing. In the UK, currently one million patients live with the physical and emotional discomfort caused by non-healing wounds. This project will help bring to the clinic a unique, revolutionary cure that will accelerate wound healing by removing biofilms.	University of Sheffield	Neem Biotech and Welsh Wound Innovation Centre
Facile fabrication of a disruptive titanium technology using a polydopamine capturing platform	Titanium dental implants to replace damaged or missing teeth can sometimes get infected. We have taken inspiration from how edible mussels attach to rocks, jetties etc. by applying a thin film of the adhesive used by mussels on titanium. The film in turn can "hook" suitable agents to minimise infection.	University of the West of England (UWE), Bristol	OsteoCare

PROJECT TITLE	PROJECT SUMMARY	UNIVERSITY/ RESEARCH INSTITUTION	COLLABORATOR/S
Biofilm fluorescent antibiotics assay	The ability of antibiotics to penetrate the biofilm matrix is key to their clinical success, but hard to measure. We will assess a novel method to detect how well antibiotics penetrate biofilms in chronic lung infections. We will use fluorescently-tagged antibiotics within clinically relevant and UKAS accredited biofilm methods.	University of Warwick	Perfectus Biomed Ltd
Development of synthetic biofilm for calibrating the effect of coatings on reducing marine viscoelastic drag	Marine fouling biofilm contributes to thousands of tonnes excess fuel usage in the shipping industry. We will develop a test system that can more accurately predict how a coating may reduce biofilm viscoelastic drag to aid in the design and application of better, environmentally friendly coatings for marine vessels.	University of Southampton	International Paint Ltd (AkzoNobel)
QuorumClean	This project aims to develop a novel marine antifouling technology that outperforms conventional approaches, but with a reduced environmental impact. The approach works by disrupting cell-to-cell communication between marine microbes. Potential applications of the technology are diverse and include protection of ship hulls, marine sensors, desalination membranes and aquaculture infrastructure.	Plymouth Marine Laboratory	Unilever R&D Port Sunlight
Advanced testing platforms to address key performance variables for antimicrobial products on domestic surfaces	Unravelling the effects of soiling events and surface chemistry on bacterial adhesion and biofilm formation over domestic surfaces under realistic environmental conditions. Moving away from model surfaces to add hierarchical levels of complexity: surface materials (hard surfaces initially); and biological inputs (single bacteria to multi-species colonies and associated soils).	University of Liverpool	Unilever R&D - Homecare Division
Treatment of zinc-contaminated slurry in steel production by BioElectrochemical Systems	In Steel industry, Basic Oxygen Steelmaking (BOS) generates significant amount of dust with high Fe contents. The presence of zinc limits Fe recovery as it would cause operational issues, leading to large amounts of dust being stockpiled. We propose a novel and sustainable BioElectrochemical System (BES) to tackle this challenge.	Newcastle University	Tata Steel Europe
Novel pharmaceutical agents (XF-drugs) to prevent and proactively manage bacterial biofilm and fungal infections in dynamic model systems	Antibiotic-resistant bacteria, particularly within biofilms and fungi pose a significant healthcare threat including respiratory conditions (e.g. Cystic Fibrosis) and chronic wounds such as diabetic foot ulcers (DFU). The purpose of this NBIC study is to examine the effectiveness of a novel antimicrobial-drug series in two mechanistically distinct and clinically relevant model systems.	University of Southampton	Destiny Pharma Plc
Development of next generation synergistic antibiofilm treatments for wounds	Over 50% of chronic wounds develop localised infection due to biofilms, impeding wound healing. Current antimicrobials in wound care have limited effectiveness against biofilms. The aim is to determine the feasibility of combining new synergistic antimicrobial and antibiofilm agents into one formulation for incorporation into a hydrogel-based low adherent fibrous wound dressing.	University of Leeds	T-EDTA Ltd, Medipure Ltd and 5D Health Protection Group Ltd
Influence of phosphate dosing to prevent plumbosolvency on biofilm formation in drinking water distribution systems	Phosphate is added to drinking water to minimise lead dissolution from household pipes. However, phosphate, can favour microbial biofilm formation in drinking water systems. To optimise the way this chemical is used by water utilities we need to understand its impact on biofilm formation and on water quality and safety.	University of Sheffield	Dŵr Cymru Welsh Water (DCWW)
Biofilm evolution in microbial fuel cells fed Yeo Valley wastewater	Yoghurt production generates wastewater that requires considerable energy to clean. This project will look at cleaning dairy waste using bacteria that release electricity as a by-product. We will examine which groups of bacteria (biofilms) are best at producing power and where to find them in Yeo Valley's wastewater treatment plant.	University of the West of England (UWE), Bristol	Bio Loop and Yeo Valley

Proof of Concept 2

AWARDED JULY 2019

PROJECT TITLE	PROJECT SUMMARY	UNIVERSITY/ RESEARCH INSTITUTION	COLLABORATOR/S
Algae-powered microprocessors	We have shown that algal biofilms can generate small amounts of electrical power, which can be used to run small electronic devices. We aim to prove the concept that we can use a conveniently sized algal biofilm to power a microprocessor - a computer powered by algae.	University of Cambridge	Arm Ltd
Development of the first ESPRIT-AM antimicrobial self-sealing vascular access graft	Implanted medical devices improve quality of life for millions of people. However, a major complication of these devices is biofilm infection. Current implantable devices offer little resistance to biofilm formation. This project will develop novel anti-biofilm medical device coatings to reduce the incidence and severity of biofilm infection.	Nottingham Trent University	ESP Technology Ltd and Harman Technology Ltd
Enhanced biofilm detection methods and the use of UVC light in their remediation and control on historic buildings and artefacts	Biofilms growing on historic buildings and artefacts can cause serious damage, with critical implications for their conservation. This collaboration with Historic England will investigate novel on-site biofilm detection methods and the use of UV-C as a cost-effective, reliable and non-destructive remediation tool for many endangered historic buildings.	University of Portsmouth	Historic England and Isle of Wight Heritage Service, Isle of Wight Council
e-Biofuels from CO2 conversion using microbial electrosynthesis	e-biosynthetic fuels from alternative resources rather than petrochemicals are essential to transition to a low carbon future with reduced green gas emission to tackle climate change, whilst meeting energy security. Microbial electrosynthesis is a promising way using microorganisms and renewable energy to convert CO2 to fuels and chemicals.	Loughborough University and Newcastle University	Shell Research Ltd
Electrical sensors for environmental & civil engineers: *in situ* online biofilm characterisation	Quantifying biofilms in drinking water pipe networks currently relies on removal of samples for laboratory analysis, which suffers from limits-of-detection, and is intrusive, costly and time-consuming. We propose a new electrical sensor to detect and quantify biofilms *in situ* and in real-time, validating against current state-of-the-art laboratory measurements.	University of Sheffield	Environmental Monitoring Solutions Ltd and Water Industry Process Automation & Control
Gas plasma for the prevention and management of osteomyelitis biofilms	Osteomyelitis is a biofilm infection of bone which is difficult to treat. This project will develop a novel laboratory testing model to evaluate and optimise a plasma treatment for osteomyelitis biofilm infections.	University of Hull	Adtec
Examining the potential of pharmaceutical agents (XF-drugs) to prevent and proactively manage bacterial and fungal infections in a dynamic *ex vivo* ocular model system	Antibiotic-resistant bacteria and fungi pose a significant threat in ophthalmic e.g. microbial keratitis, resulting in vision impairment and blindness particularly in lower to middle income countries. The purpose of this study is to examine the effectiveness of novel antimicrobial-drugs, against clinically relevant bacterial and fungal species in a model system.	University of Sheffield	Destiny Pharma plc

PROJECT TITLE	PROJECT SUMMARY	UNIVERSITY/ RESEARCH INSTITUTION	COLLABORATOR/S
In situ underwater optical sensors	There is a growing market in the Marine and Freshwater sector for *in situ* sensors to monitor water environments. A significant bottleneck is rapid instrument failure due to biofouling of sensor windows. This project will: (i) create smart antibiofouling windows; (ii) modify and upgrade current sensors for underwater biofilms identification.	University of Liverpool	Chelsea Technologies Group Ltd
Branched functional polymers for disrupting bacterial biofilms	Biofilms in wounds and on medical devices are a major problem that prevent the treatment of infection. They are produced by infecting organisms and protect it from treatment with antimicrobials and antibiotics. In this project awe are using nanotechnology to disrupt these films to expose the organisms to treatment.	University of Bradford	5D Health Protection Group Ltd
HullSense	We will design, build and test a working prototype biofilm sensor that will sense microfouling, in real time on ship's hulls. This direct measurement of biofilm will allow in-water hull cleaning to be correctly scheduled to: extend longevity of coatings, reduce fuel consumption and reduce green-house gas emissions.	Plymouth Marine Laboratory	Valeport Ltd
Development of new antibiofilm agents through repurposing of existing licensed drugs	We have recently demonstrated the potential to repurpose existing drugs already used in human medicine as antibiofilm agents. This project will provide a comprehensive screen of available drugs to identify the best candidates for repurposing as antibiofilm agents, with an initial focus on catheter associated urinary tract infection.	University of Bath	Public Health England and King's College London
Detection of biofilms that give rise to wound infection; development of a prototype point-of-care device based on rapid detection and analysis of microbial volatiles	Wound infection results in poorer outcomes for patients and higher costs for the NHS. We aim to detect the gases produced by microorganisms that cause wound infection using nanomaterial based sensors. This Proof of Concept device could potentially lead to future production of a novel point-of-care diagnostic tool.	University of the West of England (UWE), Bristol	University Hospitals Bristol NHS Foundation Trust and Altered Carbon
Bacterial networking; why it's not always beneficial to build bridges and make connections	Bacteria in wastewater treatment works can form complex network-like structures that can be detrimental to the treatment process. In this Proof of Concept project, we will perform experiments and computer simulations to understand the mechanisms by which these structures form. The insight gained will help us inhibit their occurrence.	University of Edinburgh	Veolia UK
Developing passive RFID technology to monitor *Candida albicans* biofilm growth on medical devices	Pathogenic yeasts can grow as biofilms on materials used to make medical implants, this represents a significant infection risk to vulnerable patients. We will develop methods to detect biofilm growth on medical devices within patients and in real-time using radio-frequency identification (RFID) technology, this will help improve diagnosis and treatment.	University of Kent	Smiths Medical International Ltd
Label-free multimodal imaging platform for detection of biofilms	Biofilms are groups of bacteria that are very difficult to detect. We're combining powerful chemical and molecular technologies in a volumetric imaging platform to analyse biofilms quickly through their unique characteristics. This will help in diagnosis, treatment avoiding anti-microbial resistance and remove or promote biofilms in health and industrial applications.	University of Southampton	M Squared Life Ltd and University Hospital Southampton

PROJECT TITLE	PROJECT SUMMARY	UNIVERSITY/ RESEARCH INSTITUTION	COLLABORATOR/S
Rapid screening platform for shortlisting coatings against infection	Urological devices are widely used to treat kidney stones, tumours, and incontinence. However, they significantly suffer from biofilm formation, causing severe side effects. Here, we will develop the first microfluidic platform for rapid screening of coatings that prevents/addresses biofilms, enabling development of safer urological devices and with wider potential applications.	University of Southampton	Public Health England and Center for Biofilm Engineering (CBE) Montana State University
Advanced biofilm removal mediated by targeted microbubbles generated by fluidic oscillation	In this proposal we will develop an innovative multidisciplinary approach to identify key components of bacterial physicochemical characteristics of both static and dynamic biofilms, which will provide a biomarker for biofilm stability and a target for biofilm removal using our patented novel technology of microbubbles generated by fluidic oscillation.	University of Sheffield	Perlemax Ltd
Automated *in situ* detection and monitoring of marine biofilm erosion and mechanical properties via custom optical coherence tomography (OCT)	This project aims to adopt a uniquely designed automated *in situ* testing rig to detect and monitor marine biofilm erosion and study their mechanical properties. This would address the influence of biofilms on the drag on marine vessels with the aim of improving development of anti-fouling coatings to reduce fuel costs.	Newcastle University	International Paint Ltd (AkzoNobel) and University of Southampton
Validation of the Oxi-Cell Ozone System for the elimination of biofilms	Oxi-Tech have developed the ozone producing technology Oxi-Cell to combat bacterial biofilms. Oxi-Cell is fitted in-line to water systems to inhibit microbial growth. To validate this technology and facilitate the commercial uptake of Oxi-Cell, we will quantify the antimicrobial effects of this system on planktonic and biofilm populations.	University of Southampton	Oxi-Tech Solutions
Plasma for the prevention and management of chronic wound biofilms	Chronic wounds are costly to treat and significantly affect a patients' quality of life. Bacterial biofilms (specific bacterial structures) play an important role in chronic wounds, and are responsible for many antibiotic treatment failures. This project will test an exciting new technology to remove wound biofilms and promote healing.	University of Hull	Fourth State Medicine
Development of a non-thermal plasma applicator for the decontamination of medical endoscopes	This project will develop a novel non-thermal plasma applicator system for the decontamination of medical endoscopes during re-processing within hospital facilities. This addresses the current clinical and economic need to ensure that endoscope devices are free from the risk of cross contamination and potential infection for patients.	University of the West of England (UWE), Bristol	Creo Medical Ltd and Pentax Medical
Standardised complex wound biofilm models - a robust antimicrobial screening tool	Biofilms are rarely found comprised of one single type of microorganism, yet the development of new antimicrobials tends to focus on testing one bacteria. This project aims to develop methods and testing platforms that will allow industry partners to develop an effective anti-biofilm compounds using a platform representative of wounds.	University of Glasgow	BluTest Laboratories
Rapid early and accurate diagnosis of wounds	To feasibility test an optical-fluorescence-based detection technique that seeks to quantitatively detect bacterial biofilms in infected wounds against a complex background of normal flora, and determine antibiotic susceptibility. The rapid single-step test, implementable at the bedside, can potentially transform wound care through improved clinical outcome and reduced costs.	Loughborough University	Smith+Nephew Ltd
Commercialisation of a burn wound biofilm model to provide a new service for pre-clinical research and testing in academia and industry	Biofilm formation in burn wounds is associated with treatment failure, poor clinical outcomes, and development of chronic non-healing wounds. This project will develop a UKAS-accredited pre-clinical model of burn wound infection, that can support both early-stage and commercial development of new products to control biofilm formation in wounds.	University of Bath	Perfectus Biomed Ltd

Proof of Concept 3

AWARDED MAY 2020

PROJECT TITLE	PROJECT SUMMARY	UNIVERSITY/ RESEARCH INSTITUTION	COLLABORATOR/S
Develop a computational tool for marine biofilm management	Computational biofilm modelling has potential as a rapid, low cost route to accelerate ship fouling control coating research & development. This project aims to develop a unique computational tool to predict experimental data on marine biofilm erosion, deformation and drag at mesoscale flow cell as a Proof of Concept.	Newcastle University	International Paint Ltd (AkzoNobel) & University of Southampton
Biofilm production of *Phaeodactylum tricornutum* for fucoxanthin	A membrane-based bioreactor system utilising biofilm forming microalgae has been developed to solve the economic and biological bottlenecks commonly associated with conventional microalgal production. This study will establish the economic viability of this novel process using the model marine diatom *Phaeodactylum tricornutum* for the production of the high-value pigment fucoxanthin.	Plymouth Marine Laboratory	Varicon Aqua Solutions
Novel XF drugs in the topical management of *Candida albicans* biofilms	Oral fungal biofilms are common and responsible for a significant burden of infection in people. Successful treatment is hindered by biofilm resistance and limited numbers of effective antifungal drugs. This project will evaluate the novel XF drugs in combatting *Candida* biofilms and reducing their infection risk using mucosal mouth models.	Cardiff University	Destiny Pharma
Development of molecular support to detect biofilm causing pathogens within chronic infections	The same species of microorganisms colonize skin and behave as pathogens. The biofilm phenotype has been proposed as a trigger for infection chronicity however organisms are not routinely screened for this. This project aims to identify genetic markers linked to biofilm that can be utilised by clinicians to detect biofilms.	University of Huddersfield	Perfectus Biomed Ltd
Rotating spiral biofilm reactor for reliable engineering and control of bacterial communities and environments for use in industrial biotechnology	This project extends an existing technology based on rotating spiral channels to the challenge of harnessing microbial biofilms for sustainable production of valuable chemicals currently uneconomical to synthesise through alternative routes. The constructed prototype will act as an enabling technology and open up new markets for the industrial biotechnology sector.	University of Sheffield	Unilever
Manipulation of gut biofilms dynamics for enhanced iodine bioavailability	Biofilm aggregates (diversity, function) influence nutrients bioavailability from complex food matrices. We will define how gut biofilm aggregates influence iodine bioavailability (nutrient of public health interest) from seaweed, an iodine-rich food. Defining how to sustain/engineer these biofilms will enable the industry partners to develop safe evidence-based products.	University of Glasgow	Seaweed & Co
DNA origami nanostructures as a tool in the disruption of *P. gingivalis* biofilms	We aim to fight the bacteria that contribute to gum disease, by creating origami-like DNA nanostructures loaded with antibacterial enzymes or proteins. We will optimise the DNA origami to bind specifically to the target bacteria and to improve the penetration and disruption of the biofilms that they form.	University of Cambridge	Frontier IP Group plc

PROJECT TITLE	PROJECT SUMMARY	UNIVERSITY/ RESEARCH INSTITUTION	COLLABORATOR/S
To incorporate a quorum sensing blocker (lactams) into wound dressing platforms to control biofilms	The general aim of this Proof of Concept of study is to develop and evaluate a pioneering wound dressing to be used as a new, smart technology for the effective management of biofilms in wounds, which has the potential to greatly enhance patient outcomes and reduce healthcare costs.	University of Liverpool	5D Health Protection Group Ltd, Penrhos Bio and Unilever
Biofilm disruption activity of absorbent sustained action alginate and iodine combined wound dressings	Potential methods to treat wound infections include using absorbent dressings containing alginate for antimicrobial sustained-release. Alginate-Iodine combinations have shown considerable promise against single-species biofilms. Here we evaluate disruption of persistent polymicrobial inter-kingdom and single-species wound biofilms utilising different formulations of absorbent sustained-action alginate/ iodine dressings in abiotic and biotic biofilm models.	University of Nottingham	Io-Cyte Ltd and University of Southampton
Novel hybrid biofilm technology to remove nutrients from wastewater	Nutrient removal represents a significant challenge to the water industry, housing development and local economy, particularly in the Solent region. This project aims to demonstrate a hybrid biofilm system in a full-scale prototype plant achieving total nitrogen and total phosphorus concentrations below 5 and 0.5 mg/L, respectively, in treated effluent.	University of Southampton	Plantwork Systems Ltd
Dry surface biofilms, understanding their formation and development of a test model for preventative surface cleansers	Surfaces within a healthcare environment can be coated with potentially infectious organisms which survive by forming a dry biofilm. The project seeks to further understand the form and function of these biofilms whilst generating a test method to assess preventative surface cleansers.	University of Huddersfield	Genesis Biosciences

Proof of Concept 4

AWARDED JUNE 2021

PROJECT TITLE	PROJECT SUMMARY	UNIVERSITY/ RESEARCH INSTITUTION	COLLABORATOR/S
An industrial whole organism assay for biofilms made by pathogenic bacteria without the use of laboratory mammals	Pharmaceutical companies require reliable biofilm assays. Current tests are performed in cultured cells. We will develop colour-based assays to monitor biofilm formation by the pathogen *Pseudomonas aeruginosa* in the transparent nematode *Caenorhabditis elegans*. Assays using fluorescent markers and health readouts in this animal will be faster and cheaper than mammals.	University of Kent	Magnitude Biosciences and Perfectus Biomed
Utilising biofilm-driven mineral precipitation for sustainable construction materials and a healthy built environment	This project will apply a bacteria-based construction technology (BBCT), driven by biofilm-formation, to improve the performance of a new eco-friendly, breathable plasterboard. BBCT can produce limestone films on material surfaces, and here we will use it to modify hemp particles for improved strength when added to the new plasterboard technology.	University of Bath	Adaptavate
Endolysin technology for selective management of MRSA biofilms on skin and wounds	Antibiotic-resistant bacteria (MRSA) are frequently found on the skin of hospitalised patients, leading to infection and poor wound healing. This project will test whether an enzyme (endolysin) is able to safely and selectively kill skin and wound MRSA without damaging the beneficial skin bacteria.	University of Hull	Cica Biomedical Ltd and Micreos
Targeted protein payload dispersal of vaginal biofilms	Bacterial vaginosis (BV) represents both a significant health and economic burden. Commonly associated with this infection is treatment failure due to the presence of microbial communities known as biofilms. In this project we aim to develop testing platforms to assess the efficacy of a novel therapeutic targeting BV.	Glasgow Caledonian University	CC Bio and University of Glasgow
Assessing the potential of a recombinant anti-biofilm protein as a cost-effective, environmentally-friendly treatment against souring and biocorrosion	This project investigates the potential of an abundant, naturally-occurring protein, increasingly used in clinical applications, for preventing and controlling industrial biofilms, to reduce problems such as toxic gas production and biocorrosion, and the need for biocides.	Heriot-Watt University	Virustatic
Developing novel antimicrobial surfaces preventing biofilms in the rail and transport industry	NitroPep and the University of Birmingham are developing a novel technology which could prevent bacterial adhesion and biofilm growth on frequent touch surfaces such as those in public transport in trains and buses.	University of Birmingham	NitroPep

PROJECT TITLE	PROJECT SUMMARY	UNIVERSITY/ RESEARCH INSTITUTION	COLLABORATOR/S
Organo-metallic HIPIMS-coated antibiofilm advanced wound dressings	This study will explore the application of antibiofilm nanoscale organo-metallic coatings to advanced woundcare dressing substrates using the low environmental impact processes of HIPIMS and aqueous application. This new class of wound dressings would have the potential to greatly enhance patient outcomes and significantly reduce healthcare costs.	Sheffield Hallam University	5D Health Protection Group Ltd
The standard biofilm: a reference measurement system to support routine manipulation, innovation and application	Methods and materials to support the standardisation of biofilm analysis which are lacking in all industrial sectors where biofilms are important. This project aims to address this need by developing methods to produce and characterise reference materials to validate biofilm analysis and technical approaches used in various industrial sectors.	University of Southampton	LGC Ltd
Novel approach to treat osteomyelitis biofilms combining innovative dual therapy and slow drug release	Osteomyelitis is a bone disease mostly caused by biofilms in bone injuries or surgical sites sometimes leading to bone removal. We will use a novel approach to treat osteomyelitis biofilms combining innovative dual therapy targeting bacterial communication mechanisms with antibiotics and slow drug release.	University of Nottingham	Ceramisys Ltd and Upperton Pharma Solutions
Evaluating the antimicrobial activity of herbal infusions: implications for consumer healthcare and well-being	There is an increasing demand for natural supplements in the consumer healthcare and wellbeing market, with more people taking a holistic approach to self-care. Herbal products are widely used in traditional medicines. This study will investigate the antimicrobial effects of Pukka herb products and establish optimal effective combinations.	University of Southampton	Pukka Herbs Ltd
Antibiofilm touch point plastics	This proposal explores developing plastics on which microorganisms will not grow, either in planktonic or biofilm state. The resultant plastics, processable by typical mass production techniques will enable a huge range of end products across plastics surfaces and touch points.	University of Warwick	5D Health Protection Group Ltd
Development of an *in vitro* human skin biofilm model for testing active ingredients for hand hygiene	There is a current need for realistic efficacy assays for screening hand disinfectant products that are simple, affordable and high-throughput. In this project, we will partner with Bear Valley Ventures and Aqualution to develop a human skin biofilm model that can be used for high-throughput testing of skin disinfection formulations.	University of Edinburgh	Bear Valley Ventures and Aqualution Systems Limited
To incorporate a quorum sensing blocker (lactams) into topical treatments to control mixed biofilms on keratinaceous infections	The general aim of this proof of concept study is to develop and evaluate a pioneering topical skin treatment to be used as a new smart technology for the effective management of complex biofilm infections. This has the potential as an alternative for anti-microbial resistant infections and reduce healthcare costs.	University of Glasgow	Unilever and Penrhos Bio

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Bioinspired protein technology for biofilm prevention on indwelling medical devices	Biofilm formation on indwelling medical devices, such as ventilators or catheters, contributes significantly to the chronicity of infections, posing a substantial healthcare and economic burden. This project will investigate incorporation of natural protein-based technology to indwelling medical devices, and its effectiveness against biofilm formation.	University of Liverpool	Virustatic
Accelerating innovation by designing water treatment biofilm media *in silico*	We should design water-treatment biofilms like we design Formula 1 racing cars: in a high-performance computer. From models of individual bacteria, incorporating realistic chemical and mechanical properties, we will show we can design a new generation of treatment biofilm media *in silico.*	Newcastle University	Veolia Water Technologies and Northumbrian Water Ltd
Development of novel biomimetic surfaces to prevent biofilm formation on catheters	This project aims to develop novel biomimetic antibiofilm surfaces for catheters without using antibiotics or other antimicrobial agents. This would address catheter associated biofilm infections with the aim of improving development of anti-fouling surfaces to prevent biofilm formation in the long-term.	Newcastle University	Teleflex Medical Europe Ltd and University of Southampton
Development of an electrospun antimicrobial coated tampon for management of bacterial vaginosis	Bacterial vaginosis (BV) affects women aged 15-44 years but is difficult to treat during menstruation. This project will engineer a tampon with unique additional layers containing a smart antimicrobial protein that is released during use to manage the bacteria that cause disruption to the normal biofilm of the vagina causing BV.	University of Bradford	Virustatic
Rapid easy-to-use and affordable diagnostics for wound - 2	A point-of-care wound diagnostic test under development will be validated for rapid quantitative detection of bacterial load and antimicrobial sensitivity using clinical isolates of a range of wound relevant bacterial strains and wound samples. Successful validation will be progressed towards further optimization and clinical trial supported by an external grant.	Loughborough University	Smith+Nephew Ltd, Birmingham City University, Lancaster University and Cromerix Ltd

External Image Credits

Front cover: 'Kaleidoscopic biofilm'. An abstract depiction of a biofilm growing in a tubular structure. Painting by Aryana Zardkoohi-Burgos from the University of East Anglia and Quadram Institute Bioscience.

Page 2: 'Holey Moly'. x20 image of a *pseudomonas aeruginosa* biofilm, featuring dark circles pockmarking the surface. Image by Christopher Campbell from the University of Southampton.

Page 4: 'Prokaryotic Plumes'. A false-coloured confocal fluorescence image of *E. coli* cells shedding from a disrupted biofilm. Image by Liam Rooney from the University of Strathclyde.

Page 22: Multispecies biofilm derived from oral samples. Image by Gordon Ramage and Mark Butcher from the University of Glasgow.

Page 24: A polymicrobial biofilm of *Candida albicans* in yellow, *Staphylococcus aureus* in magenta and *Pseudomonas aeruginosa* in cyan, grown for 48h with 5% oxygen (hypoxic) then imaged on confocal microscopy. Image by Shaun Robertson from the University of Nottingham.

Page 25: 'Egg'. An egg shape suspended cluster found in an overnight culture of *Staphylococcus aureus* (fluorescent green, nucleic acid stained). Image by Jiaqi Luo from the University of Liverpool.

Page 27: 'Planetary Cover Description'. Bacterial colonies on a petri dish, looking like a solar system. Image by Mason Giles and Fen Sawyer from the University of Southampton.

Page 29: '*E. coli*' ©2017 CBE-MSU. L. Lorenz.

Page 35: Biofilm Engineering and Biofilm Prevention workshop illustrations. Tom Bailey.

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