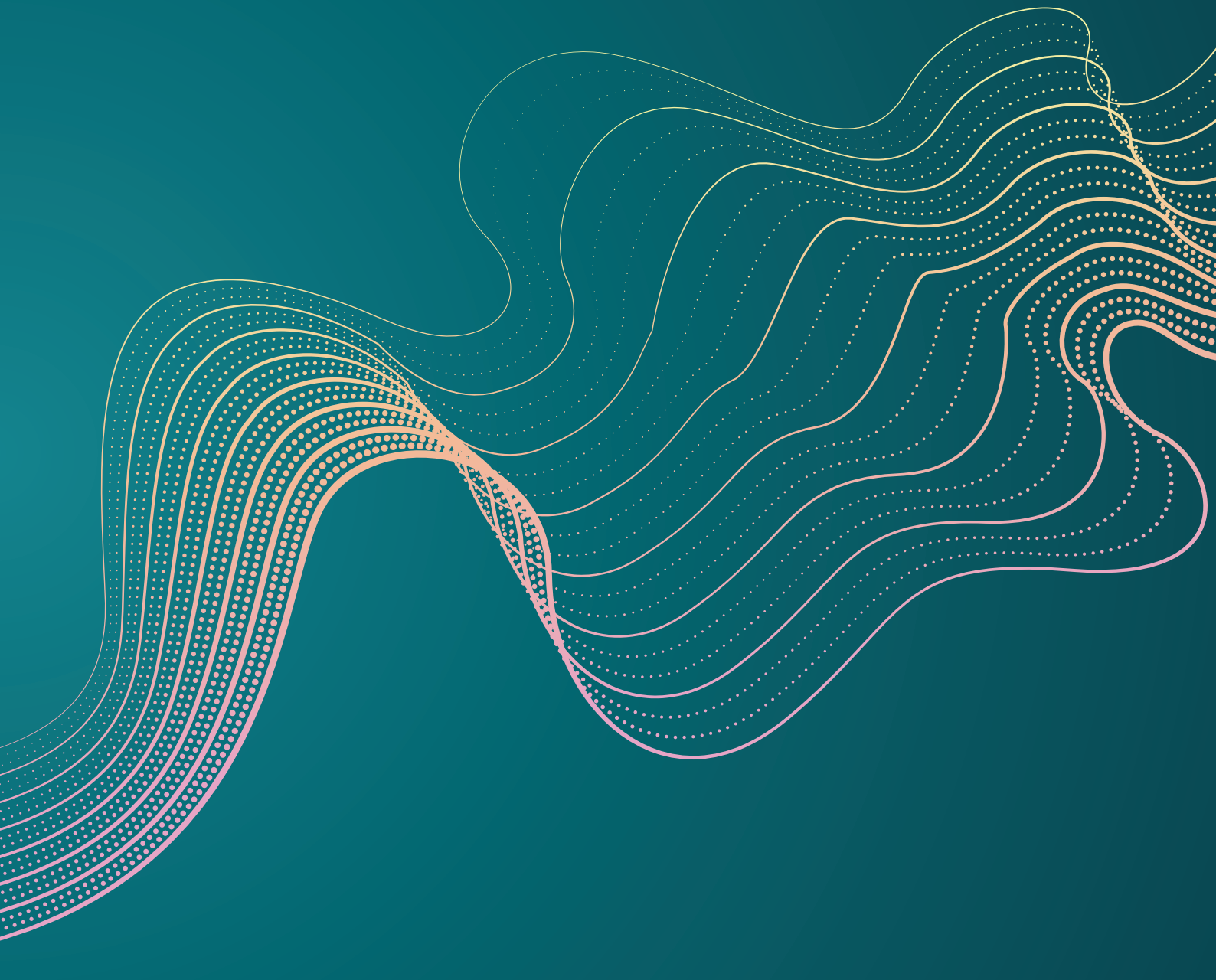
National Biofilms Innovation Centre

Annual Report 2019

HARNESSING THE UK'S ACADEMIC AND INDUSTRIAL STRENGTH IN BIOFILMS



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NBIC ANNUAL REPORT 2019

Foreword

A FEW WORDS FROM OUR CEO

The National Biofilms Innovation Centre (NBIC) is an inclusive and open partnership of UK researchers and companies working collaboratively on our goal of harnessing the UK's academic and industrial strengths in biofilm research to deliver economic and societal value to the UK.

I was heartened from day one that every university and company we met with felt just as passionately about making a difference in this field as we did and were keen to be collaborative wherever possible. Whenever we have asked for help, the community has supported us, be it in reviewing POC applications, attending workshops, hosting our visits (and answering our naïve questions) or sitting on advisory boards and panels. Thank you. In our first 18 months I have been mindful that we need to set up lean ways of working and focus our energies on delivering value to our community of researchers and industrial partners. I joined NBIC from a career in a regulated industry setting and I felt liberated in setting up a team and culture that was geared to easily connect and support the biofilm community. I'm very proud that through our accession process we now have 45 UK Research Institution members across the UK (plus strong international relationships in the US, Singapore and wider). Through the work of our innovation team, we have an engaged network of over 100 companies from multiple sectors who have directly engaged with us in understanding unmet needs to inform our direction. Since June 2018, we have run two Proof of Concept project calls, funding a portfolio of 51 projects and investing a total of over £2m. We have also held two workshops with close to 200 attendees. In addition, through our BBSRC funding, we have now recruited 14 Interdisciplinary Research Fellows in our 4 core partners to help drive the scientific agenda.

This is just the beginning, and we still have so much to deliver and innovate in our coming years (entrepreneurial training, scientific synergies, new businesses and future research leaders). Like any start-up, we now need to develop this continuing community support to demonstrate we can truly create lasting value and make a difference.

- MARK RICHARDSON, CEO, JULY 2019

Our Vision

RESEARCH, INNOVATE AND TRAIN

The National Biofilms Innovation Centre 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 impact. NBIC was launched in 2017 to address these challenges and unmet needs, 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 (Southampton, Nottingham, Liverpool and Edinburgh) and a partnership that has now expanded to include 41 associate Research Institutions (RIs), support from a growing base of more than 100 companies, and an inclusive strategy to new companies and RIs. This brings an unprecedented set of capabilities, and a huge potential for innovation and collaboration that will allow us to lead on a global stage with the world's leading biofilm research institutions. By combining our collective talent, we will grow the next generation of research leaders and entrepreneurs delivering growth and wealth creation in the UK and beyond.

Our Achievements

SINCE 2017

2017

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

2018

FEBRUARY 2018, CONTRIBUTED TO KTN WORKSHOP
NBIC attended and contributed to a KTN workshop on identifying and prioritising industrial challenges and solutions in controlling and exploiting biofilms.

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.

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.

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

SEPTEMBER 2018, FIRST NBIC WORKSHOP & THEORY OF CHANGE 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 increasing the UK economy.

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 approx. £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.

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

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

MARCH 2019, MOU SIGNED WITH SCELSE IN SINGAPORE
We signed an MOU with 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.

APRIL 2019, SECOND NBIC WORKSHOP HELD, SECOND PROOF OF CONCEPT CALL LAUNCHED & RECEIVED INTERNATIONAL WORKSHOP AWARD
Our workshop on Biofilm Engineering was held in Edinburgh, bring 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'.

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.

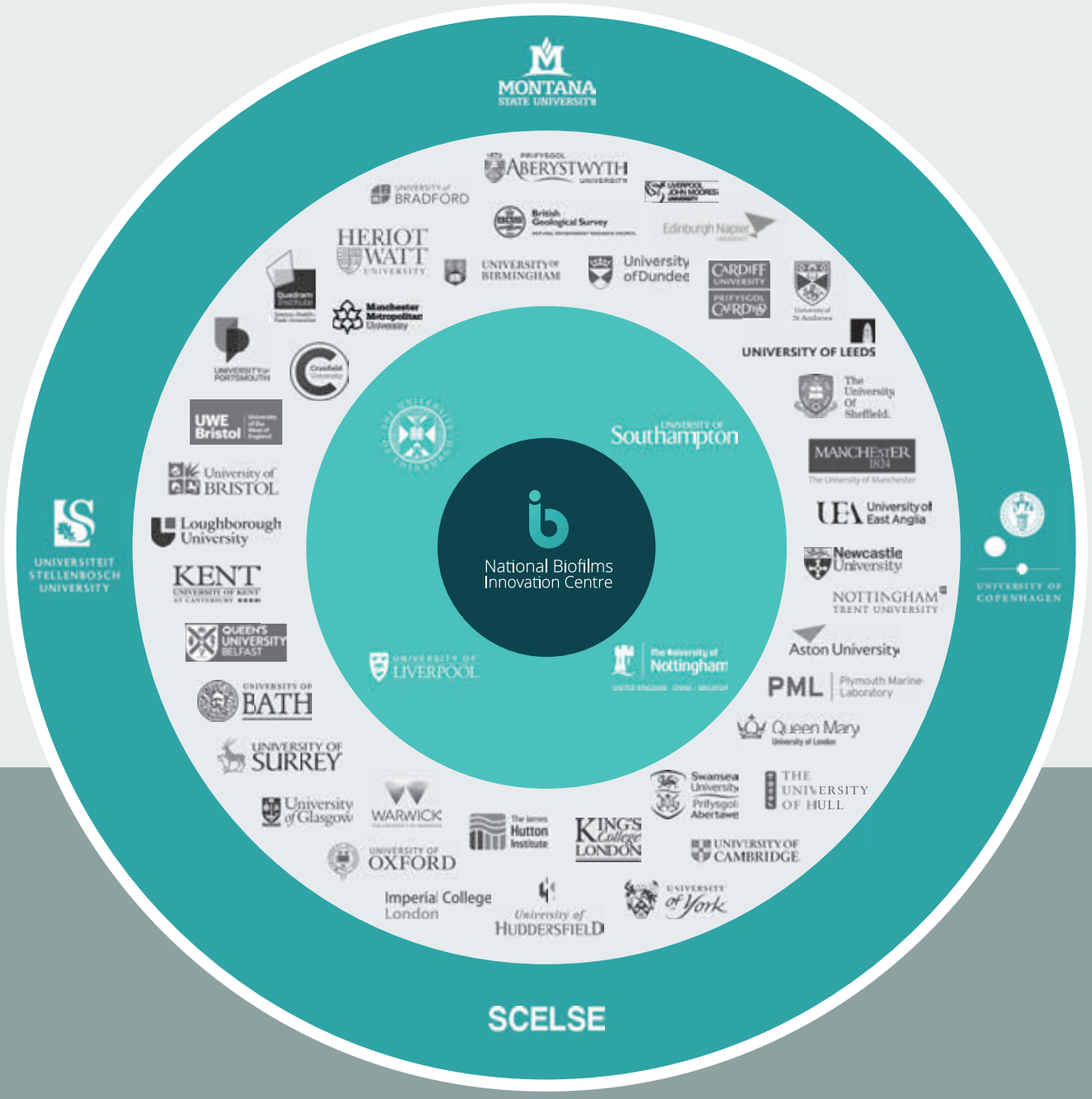
JUNE 2019, 3RD WAVE ACCESSION
14 new research institutions joined the NBIC consortium, bringing us to a total of 45.

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.

NOW,
Over 100 industry partners.

Building an International Community

OF BIOFILM RESEARCHERS



Our Key Objectives

NBIC AIMS TO DELIVER

1. World class science
2. Meaningful and productive interactions between academic and industry members
3. NBIC sustainability
4. Economic and societal value to the UK
5. The next generation of scientific leaders
6. Raised awareness of biofilm issues and opportunities

Theory of Change

NBIC STRATEGY & GOALS

LONG TERM

FINAL GOAL:
INCREASE THE UK ECONOMY

National Biofilms Innovation Centre

THE UK'S RECOGNISED HUB FOR ACCESSING BIOFILM EXPERTISE, CAPABILITY, SCIENCE AND INNOVATION
SCIENTIFIC, COMMERCIAL, ECONOMIC, SOCIETAL AND ENVIRONMENTAL BENEFIT CREATED
INCREASINGLY RESPONSIVE TO SECTORAL CHANGES WITH BREAKTHROUGH INNOVATIONS

MID TERM

IMPACT & BENEFIT
- Strong national infrastructure developed & well-established Innovation Knowledge Centre (IKC)
- Economic and societal value created
- Raised public awareness of biofilms and implications on public health
- ROI - created more value

SUSTAINABILITY & LEGACY
- Research and innovation capacity catalysed
- Continued funding (aim to win £40m)
- Brand recognition
- Critical mass developed from collaboration

DIRECT OUTPUTS
- **Science**: Publications, IPs/patents, citations, facilities & services
- **Innovations**: Completed projects to industry products and spinouts
- Increased academic-industry partnerships through workshops
- NBIC roadmap for biofilms established

INTERMEDIATE OUTCOMES OVER INITIAL 5 YEARS

SHORT TERM

CONCISE OUTPUTS OVER INITIAL 2 YEARS

- Award >50 Proof of Concepts (POC) across various sectors, from health to marine, SMEs and large multinationals
- Host 4 workshops across strategic themes to facilitate knowledge exchange, business assist and networking
- Grow university and identified strategic partners with an expertise in biofilms research and innovation
- Recruit >15 Interdisciplinary Research Fellows (IRFs) and establish the NBIC Doctoral Training Centre in Biofilms Innovation, Technology and Engineering (BITE)
- Develop international collaborations with centres of excellence in biofilms
- Raise awareness of NBIC and its mission at the ASM Biofilm Conference in Washington, USA and Eurobiofilms, UK
- Establish key governance structures and a fully staffed operational team

ACTIVITIES

INTERDISCIPLINARY RESEARCH

Establishing a joined-up UK research strategy aligned with UKRI and industry strategies

Interdisciplinary working across research and sectors

Achieving a critical mass and infrastructure capability

Deepening scientific understanding of the prevention, detection, management and engineering of biofilms

Investing early in new science that show 2-4 TRL (Technology Readiness Level)

TRAINING & OUTREACH

Providing interdisciplinary training through dedicated MSc, MRes and PhD programmes to develop the next generation of scientifically agile, 'industry-ready' leaders

Delivering entrepreneurial training - from ICURe to SETsquared (#1 university-led incubator in the world) or as appropriate

Engaging with the wider biofilm community and media, regulatory bodies and policy groups, existing and new industry partners, KTN workshops and the public through outreach events and educational activities

Host an international **World Biofilms Summit** to cement NBIC as a centre of global thought leadership in biofilms

RESPONSIBLE INNOVATION

Responsibly innovating in business through commercialising R&D to generate economic benefit in the form of increased market share, GVA and high value jobs

Facilitating more industry-academic partnerships, with £5m flexible funding available to support between 80-120 projects over initial 5 years

Providing a connected innovation space for partners and industry to come together

Supporting development of biofilm management technologies through translational Proof of Concept (POC) funding

STRATEGY

OUR APPROACH

All activities will be led by a forward-thinking, interdisciplinary approach, underpinned by excellence and our values; collaborative, transparent, innovative, flexible, responsive and responsible. Through collaborating to advance relevant research, training future academics and investing in innovation responsibly, our activities will build the environment and mechanisms to efficiently explore and solve unmet sectoral needs, develop strong networks, build roadmaps, influence key stakeholders (regulators, funders and society), exploit emerging breakthroughs and take advantage of new, diverse market opportunities estimated to be worth >£2bn by 2020.

HOW WE WILL DELIVER

PREVENT | DETECT | MANAGE | ENGINEER

KEY INPUTS

FUNDING
£26m investment in NBIC from BBSRC, Innovate UK and the Hartree Centre, 45 UK Research Institutes/Universities and support from industry (>100 businesses and growing)

KNOWLEDGE & EXPERTISE
>100 researchers, including scientists, engineers, technology translators and clinicians

ASSETS & CAPABILITIES
World class strategic facilities (worth >£300m) provided by university and industry partnerships with state-of-the-art research platforms such as Predictive Modelling, Next Generation Imaging & Sensing

OPERATIONAL TEAM
A dedicated and growing NBIC operational team, providing leadership, management and support across partners and collaborators

Co-Directors

INTERDISCIPLINARY LEADS OF NBIC

Professor Jeremy Webb

Jeremy Webb is 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 discoveries in 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 Rasmita Raval

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; research group 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 Miguel Cámara

Miguel Cámara is a Professor of Molecular Microbiology in the School of Life Sciences at the University of Nottingham. He sits on the UK Cystic Trust Strategic Implementation Board 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 studying quorum sensing (QS)-mediated signaling mechanisms and their control of virulence and biofilm formation. 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

Cait MacPhee is 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.

Our Research Strategy

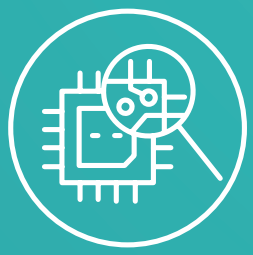
WORLD CLASS FUNDAMENTAL SCIENCE

NBIC is addressing four strategic themes: Prevent, Detect, Manage, and Engineer biofilms by capitalising on world class underpinning research and infrastructure to address sectoral challenges identified together with our industry partners. It dedicates the resource of our 14 Interdisciplinary Research Fellows (IRFs) to support the NBIC fundamental research and training strategy (60% time), and who also conduct focused Proof of Concept (POC) collaborative industry projects (40% time). Our IRFs are working with industry, funders and policymakers to refine the national research and industrial strategy agenda, shape public funding initiatives and contribute to our strategy for industrial pre- and post-competitive research. We are also developing a dedicated programme of training to build a pipeline of scientifically agile, interdisciplinary, 'industry-ready' graduates.

INTERVENTIONAL THEMES

PREVENT

Knowledge-based design of surfaces 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 community processes in process applications

Working with industry and stakeholders to define the national research strategy

NBIC's research strategy is informed by our industry partners, leading to new projects that support the development of shared sector roadmaps which identify a clear path to successful creation of value from biofilms research. Key to this is that our IRFs, who are engaged in delivering our scientific priorities, also engage and work with our industry partners, providing greater connectivity across the innovation space.

Adding value through integrating and connecting the national community and infrastructure

Connecting our four core-funded universities – Southampton, Nottingham, Liverpool and Edinburgh – and our associated partner institutions, provides a powerful critical mass of capabilities and infrastructure that provides additionality among the UK biofilms community.

This includes:

- A Data Management Plan (DMP). This is a shared data resource index for the biofilm community. A key component of our DMP is to create an index of the data generated and shared by the consortium that provides reference to the relevant Digital Object Identifiers and points of contact to ensure data is easily identified, shared and accessed across the consortium.
- Mapping facilities and infrastructure across the UK. Our joint university and industry partnerships mean that world class strategic facilities and infrastructure are available and accessible to all NBIC partners. By mapping these facilities across the community, NBIC provides a focus for connecting researchers and industry to the right expertise and infrastructure, simplifying and accelerating knowledge transfer, and catalysing collaboration to address key issues in biofilms. We are currently creating an index and map of imaging capabilities and equipment across the UK that will be made available as a shared database.

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 Southampton, Liverpool, Nottingham and Edinburgh, alongside international institutes and industry partners. It is the UK's first graduate training centre to address the skills and knowledge gap in the biofilm field. The first cohort of 12 students will start in October 2019.

The Doctoral Training Centre draws on over 70 academic supervisors from physical, mathematical, engineering, life and clinical sciences within the partner universities 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, rated 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 partner 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 Southampton**
  Microbial Ecology & Evolution; AMR; Hybrid Biodevices; Nanoelectronic and photonic devices; Bioenergy.
- **University of Liverpool**
  Functional surfaces and materials; Smart nanotechnology; Plasma engineering; Imaging; 'Omics and Bioinformatics; Microbiorefinery; Infection Control; Modelling for healthcare.
- **University of Nottingham**
  Quorum Sensing and signaling; molecular recognition; drug discovery; polymer discovery; biomedical engineering; AMR; modelling; Synthetic Biology; Advanced Microscopy.
- **University of Edinburgh**
  Soft and active matter biological physics; complex fluids and rheology; HPC modelling; biofilms architecture; Synthetic and Systems Biology.

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

Training

BUILDING ENTREPRENEURIAL SKILLS

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

Alderley Park Accelerator

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.

Innovation to Commercialisation of University Research

The ICURe Innovation-to-Commercialisation programme offers university researchers with commercially-promising ideas the ability to 'get out of the lab' and validate their ideas in the marketplace. From idea to scale-up, SETsquared offer a comprehensive range of programmes to help boost businesses to the next level.

Research Fellows

DELIVERING NBIC'S RESEARCH STRATEGY

SOUTHAMPTON

Dr Shi-qi An

Shi-qi joined NBIC in October 2018. She gained her PhD in Microbiology from Guangxi University in China and University College Cork in Ireland, as part of the SFI China-Ireland Programme. She has since held several postdoctoral positions (Queens University Belfast and University of Dundee), and has made a number of short-term research visits to institutes around Europe (Diamond Lightsource and Earlham Institute), as well as Asia (Nanyang Technological University). Her research interests currently lie in the area of bacterial virulence and stress resistance during chronic infection, with a drive towards developing new anti-infective agents for disease control.

Dr Callum Highmore

Callum's PhD focused on foodborne pathogens in the viable but nonculturable state. During his NBIC Fellowship, he will be applying Raman spectroscopy techniques for the detection and characterisation of biofilm in a range of samples spanning food and healthcare sectors, with the intent of continuing his research into nonculturable bacterial states. This research will be carried out in collaboration with the Faculties of Engineering and Physical Sciences, and Medicine, and in the first instance will assess the clinical utility of Raman spectroscopy as a diagnostic tool in Cystic Fibrosis.

Dr Joe Parker

Joe has a decade of experience understanding evolutionary and ecological relationships between organisms using DNA sequence data, spanning everything from viruses to whales and oak trees. Recently he became an early adopter of portable nanopore sequencing technology using the USB-connected MinION device, and is an expert in field-based DNA sequencing and analysis.

At NBIC, Joe applies rapid, portable real-time data collection methods and develops cloud-based, big-data analytics to produce actionable insights into biofilm species composition. He is also interested in using this data to pose deeper questions about biofilm evolutionary processes including horizontal gene transfer and antimicrobial resistance.

Dr Odel Soren

Odel's PhD project, carried out at the University of Southampton, investigated the effects of nitric oxide (NO) on biofilms formed by Cystic Fibrosis (CF) isolates of Pseudomonas aeruginosa and a novel NO-releasing class of NO-releasing anti-biofilm compounds. Her current work involves analysing data from a recent national clinical study investigating Pseudomonas aeruginosa biofilm infection in Cystic Fibrosis with the aim for finding a Pseudomonas aeruginosa biofilm biomarker. Odel is also working on a project with one of our industrial partners, Smith & Nephew, to investigate NO-based anti-biofilm wound dressings.

LIVERPOOL

Dr Yuri Diaz-Fernandez

Yuri is the Research Coordinator of the Open Innovation Hub for Antimicrobial Surfaces (OPIHAS) at the University of Liverpool. He has several years of experience in Nanotechnology, Surface Science, Chemistry of Materials, and Colloidal Chemistry. He has gained expertise on the design and synthesis of supramolecular systems and self-assembled nanostructured materials for different applications, including antibacterial surfaces, chemical catalysis, and molecular sensing. He is also involved in the characterisation of nanomaterials, surfaces, and bio-interfaces using advanced microscopy techniques. He has been actively working in challenging cross-disciplinary research activities at different research institutions across Europe.

Dr Sean Goodman

Sean obtained his PhD in Environmental Microbiology at the University of Liverpool, and has extensive research experience of culture dependent and molecular methods for microbial analysis and testing of a wide range of environments. His research projects have focused around the isolation of microorganisms from a variety of sample types and their resultant uses for industrial purposes, taxonomic analysis and genomic sequencing of microbial communities, and more recently the use of photo catalysts as antimicrobial compounds for water treatment.

Dr Fiona Mcbride

Fiona is a Postdoctoral Researcher based at the Open Innovation Hub for Antimicrobial Surfaces at the University of Liverpool. After her PhD in physical chemistry studying hydrogen bonded systems on catalytic surfaces at the University of Liverpool, Fiona took up a postdoctoral position at the University of Southampton, working in a group producing and studying high-throughput materials for a range of applications, from battery materials to memory storage. Her research interests are at the interface, not just of materials but between disciplines. Her current role spans fundamental research, and collaborating R&D projects with industrial partners.

Dr Ioritz Sorzabal-Bellido

Ioritz obtained his degree in Biomedical Engineering at the University of Navarra in Spain, and worked as a R&D process development engineer in the field of vacuum coatings. He completed his PhD in Antimicrobial Surfaces at the University of Liverpool, where he combined material chemistry, surface spectroscopy and microbiological methods to develop antibiofilm surfaces based on specific intermolecular interactions. He is currently based at the Open Innovation Hub for Antimicrobial Surfaces at the University of Liverpool, focusing on the biological response of bacterial pathogens at the cell-surface interface using high-resolution electron microscopy and time-lapse fluorescence imaging.

NOTTINGHAM

Dr Shaun Robertson

Shaun is a Research Fellow at the University of Nottingham. He completed his PhD in Microbiology at the University of the West of Scotland (UWS), investigating physical factors that affect bacterial biofilm formation. This was followed by a 2-year postdoctoral position, aiding in the continued development of a nanovibrational bioreactor (nanokicking) at UWS and the University of Strathclyde. Shaun's area of research focuses on the development of polymicrobial biofilm models and understanding the interplay between microbes present in these biofilms. He is also interested in pursuing multidisciplinary projects and is actively engaged in public engagement events.

Dr Manuel Romero

Manuel completed his PhD at the University of Santiago, exploring enzymatic mechanisms to interfere with signalling systems used by pathogenic bacteria to coordinate virulence factor production, biofilm formation and adaptation to environmental changes. At the University of Nottingham, he studied the influence of global post-transcriptional regulatory networks on selection of free-living or biofilm associated lifestyles in the pathogen Pseudomonas aeruginosa. Manuel's expertise covers molecular microbiology techniques, communication systems in pathogenic bacteria and imaging of microbial communities, as well as the discovery of potential targets for biofilm eradication and exploring the mechanisms behind new antibiofilm drugs/surfaces discovered after HT approaches.

Dr Fadi Soukarieh

Fadi obtained his degree in Pharmacy and Pharmaceutical Sciences from Damascus University, and his PhD in Medicinal Chemistry and Drug Design from the University of Nottingham. He worked on an anticancer drug discovery project targeting CDK9, and on a multinational project (SENBIOTAR) for the discovery of new PqsR antagonist as novel antipseudomonal and antivirulence agents. He joined NBIC in January 2019 and is currently focusing on the management and detection of biofilm using Medicinal Chemistry tools and approaches. This includes virtual and in-vitro screening of compound libraries, design and synthesis of small molecules and hybrid and prodrugs with enhanced permeability profiles.

EDINBURGH

Dr Susana Direito

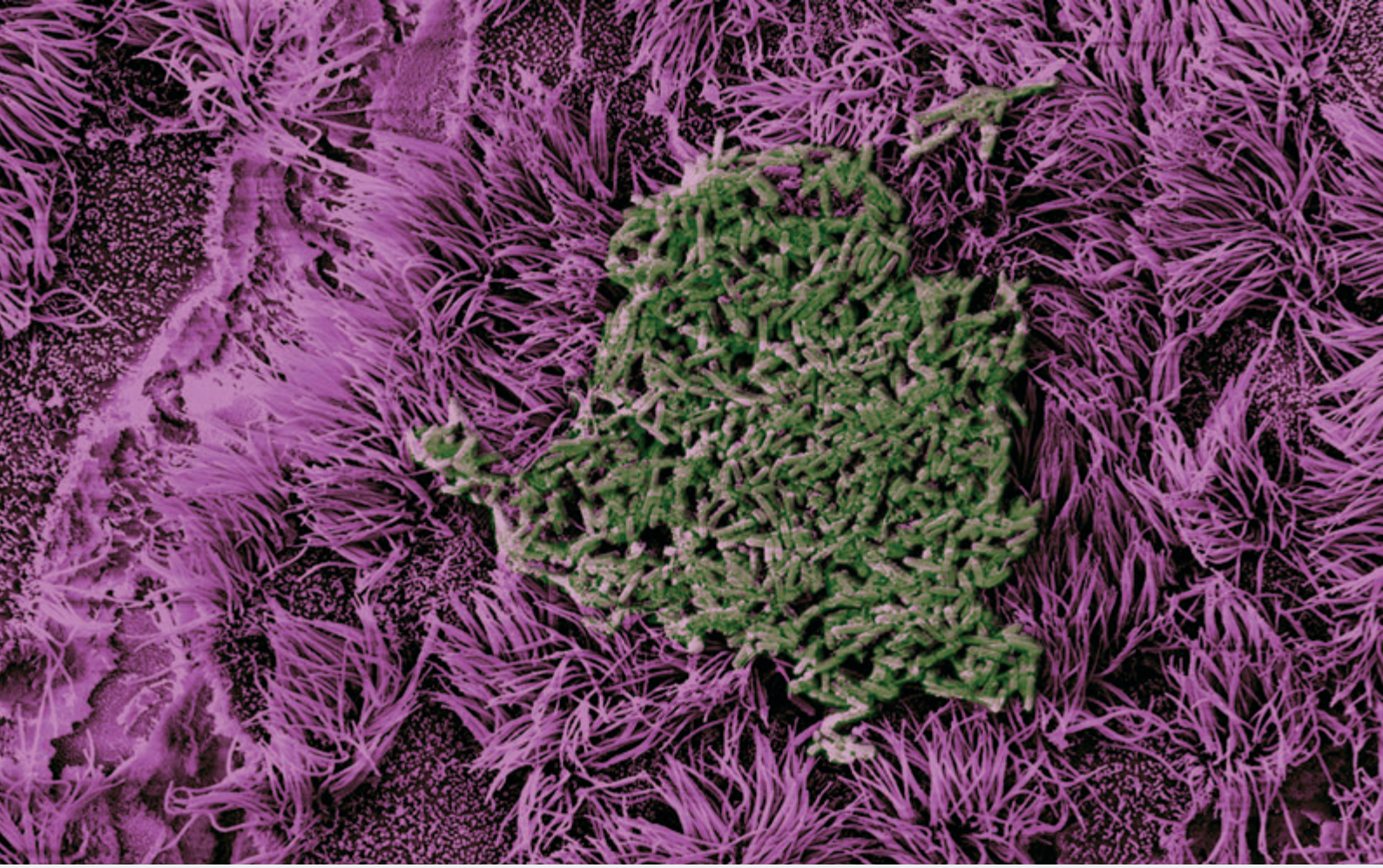
Susana is an Industrial Research Associate in Biological Physics and part of ECFP (Edinburgh Complex Fluids Partnership) core team within the University of Edinburgh. She focuses on delivering impact from research within the Soft Matter and Biological Physics group. She has expertise in microbiology and molecular biology techniques. Her scientific interests include biofilm formation, detection, eradication and advancing antimicrobial technologies. She has won awards related to these topics, including an EPSRC Impact Acceleration Award and a NBIC Proof of Concept (POC) award to study biofilm formation in venous catheters, in collaboration with a SME.

Dr Gavin Melaugh

Gavin is a NBIC Fellow in the Physics Department at the University of Edinburgh working with Professor Cait MacPhee and Rosalind Allen. Gavin studied Chemistry at Queen's University Belfast (QUB), moving to the Physics department to do his PhD in molecular modelling and computer simulations of porous liquids. This work led to the design, synthesis, and characterisation of the first ever liquids of this kind. At Edinburgh, Gavin uses a combination of experiments and computational simulations to investigate aggregation and collective phenomena in biofilm-forming bacteria such as the opportunistic pathogen Pseudomonas aeruginosa and the wastewater treatment bacteria Comamomas denitrificans.

Dr Ryan Morris

Ryan holds degrees from Boston University (B.A. Physics) and King's College London (MSc. Theoretical Physics). He completed his PhD in mechanisms of protein self-assembly at the University of Edinburgh in 2013. Since then, he's held a postdoctoral position at Edinburgh where he's studied both molecular components of biofilms, as well as investigating population-level dynamics of bacteria and biofilms. He has a strong interest in collective behaviours of bacteria and applying microfluidic technologies to better understand microbial life in spatially complex and dynamic environments.



Industry Engagement

INNOVATION AND COMMERCIALISATION

NBIC exists in order to expand, catalyse and harness the UK's academic and industrial strengths in biofilms for the long-term economic benefit of the UK.

We aim to deeply understand unmet needs in our industrial partners' contexts and markets. Through engagement, we then demonstrate the ability of NBIC Research Partners to address these needs - hence a key focus of our activities involves driving opportunities for industry and academic collaboration, support and income.

Our strategy is to match unmet industrial biofilm needs with possible solutions in order to be an essential part of our industrial partner network or open innovation pipeline. We aim to listen, understand and explore needs and capabilities to create and support connections. We can help find ways of progressing these connections either through our own funding routes (POC calls), or helping signpost other opportunities.

In the last year, we have expanded our Research Institution (RI) partnerships from the 4 core universities to 45 RIs across the UK and over 100 businesses, from micro to SME to larger corporates, each through personal engagement and contact.

We have not neglected any sector in our approach and have engaged with Health (including Oral, AMR, wound, skin, and personal care), Food, Water, Marine, Household/Cleaning, Industrial Processing, and Oil/Gas. As an Innovation Knowledge Centre (IKC) we have encountered great goodwill and support from the UK industrial and academic community, due to our pioneering approach regarding the breadth and speed of our engagement.

In addition, we are integrated in the existing UK innovation ecosystem e.g. KTNs, NIBBS, IKCs, Scottish Innovation Centres, Agritech Centres, NHS and trade organisations. These connections have informed our understanding and led to project submissions (to our own POC calls), collaborations and partner searches, where we match an industry need with a RI capability or an emerging technology in a UK RI with a suitable industry partner.

Proof of Concept Projects

SUPPORTING TRANSLATIONAL ACTIVITY

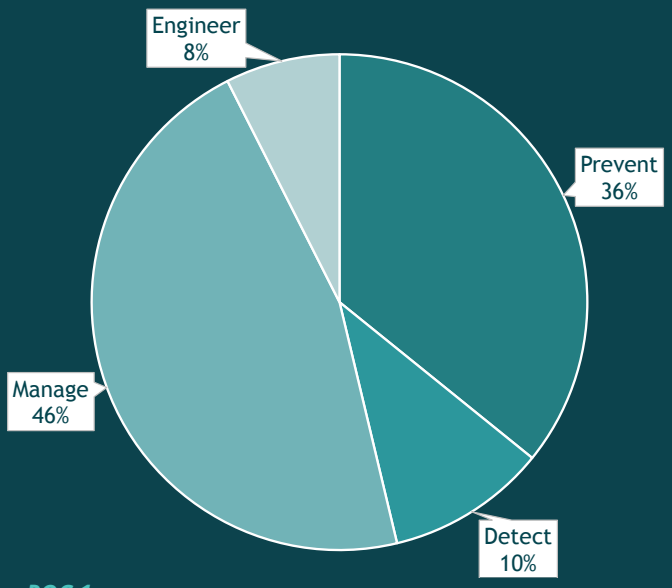
Our investment in biofilm innovation

We have carried out two calls for Proof of Concept projects amongst our community and awarded 25 projects in October 2018 and 26 in July 2019, representing a total investment of £2.79m from NBIC and an overall project value of £4.05m. A full list of projects is available from page 28.

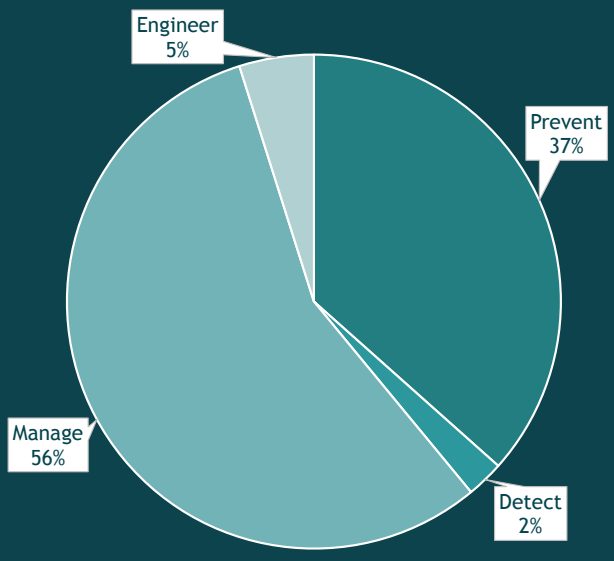
The projects establish the feasibility of a concept, idea or technology from any sector which is aimed at preventing, detecting, managing or engineering biofilms. The scope was for projects at Technology Readiness Level (TRL) 2-4, which were a collaboration between an NBIC UK RI member and an industrial partner to transfer technology IP and/or know how from the academic base.

Through work with universities and companies since our formation, we can evidence the impact this engagement has had through the broadening of the number of universities and companies awarded projects. In POC 1, for example, we had 15 RIs and 30 companies who jointly applied, and in POC 2 there were 29 RIs and 31 companies (25 of which had not applied in POC 1). We also saw a wider sectorial spread and an improved balance of interventional themes (Prevent, Detect, Manage, and Engineer) from POC 1 to POC 2.

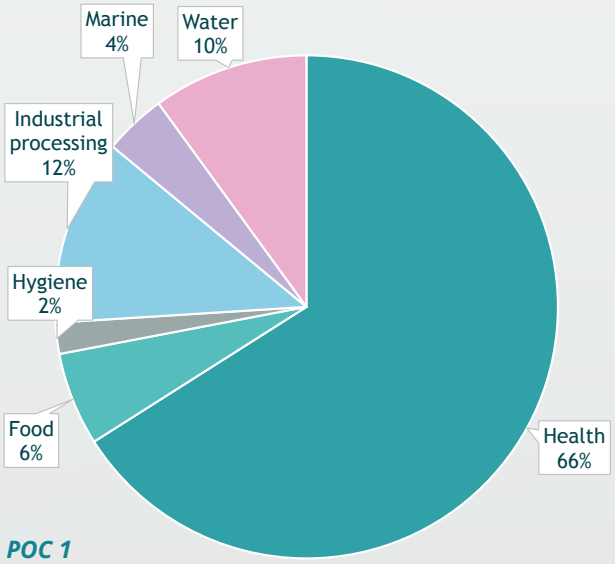
POC 1 APPLICATIONS



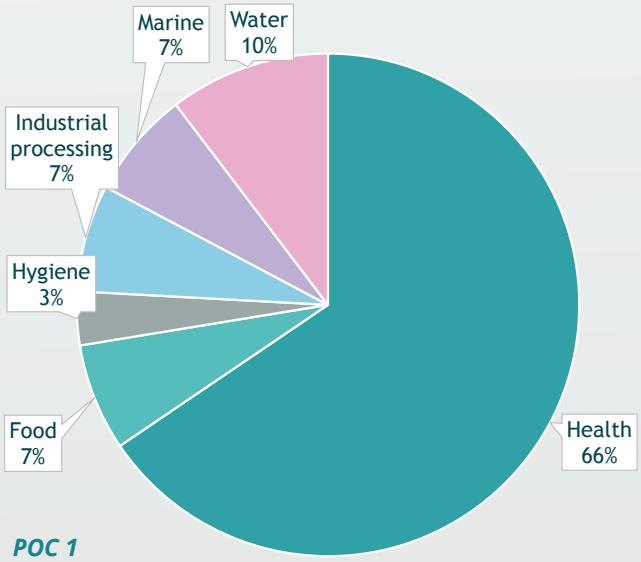
POC 1
% of project applications by interventional theme (PDME)



POC 1
% of project applications awarded by interventional theme (PDME)

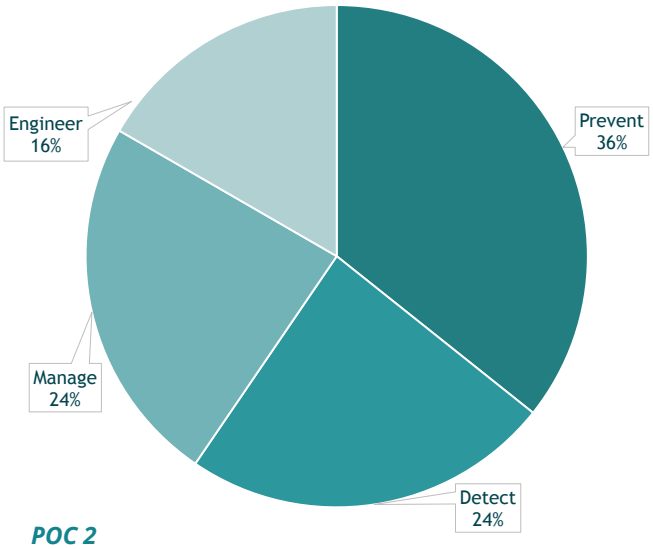


POC 1
% of project applications by industry sector

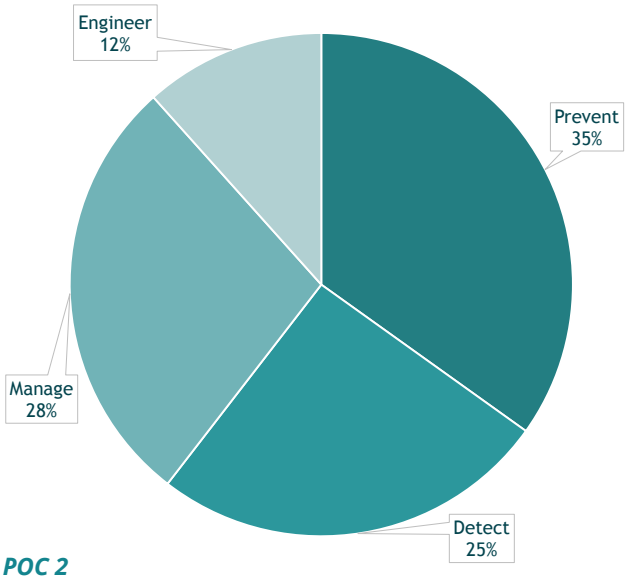


POC 1
% of project applications awarded by industry sector

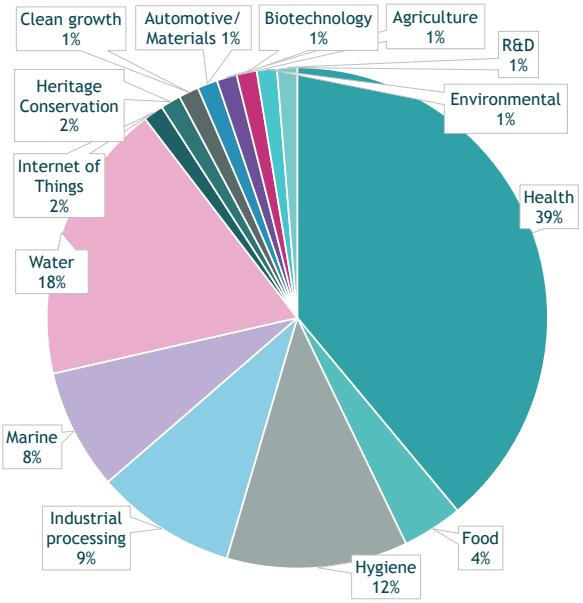
POC 2 APPLICATIONS



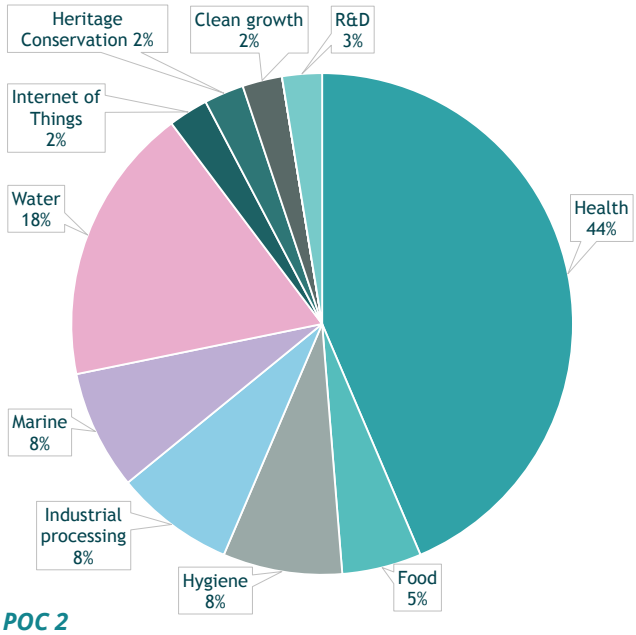
POC 2
% of project applications by interventional theme (PDME)



POC 2
% of project applications awarded by interventional theme (PDME)

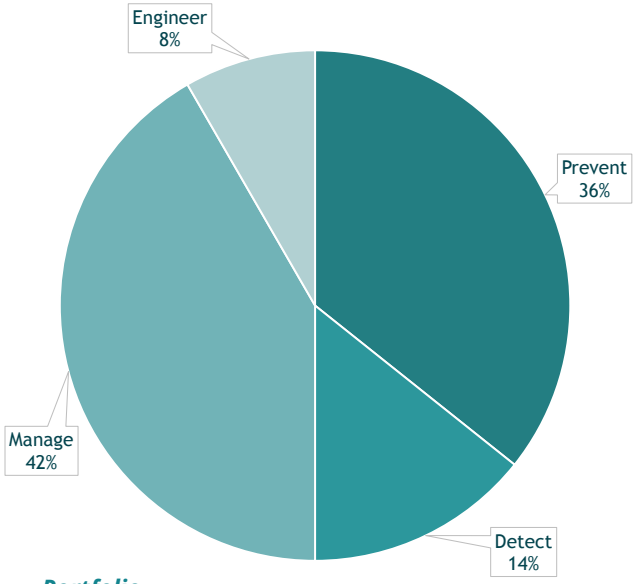


POC 2
% of project applications by industry sector

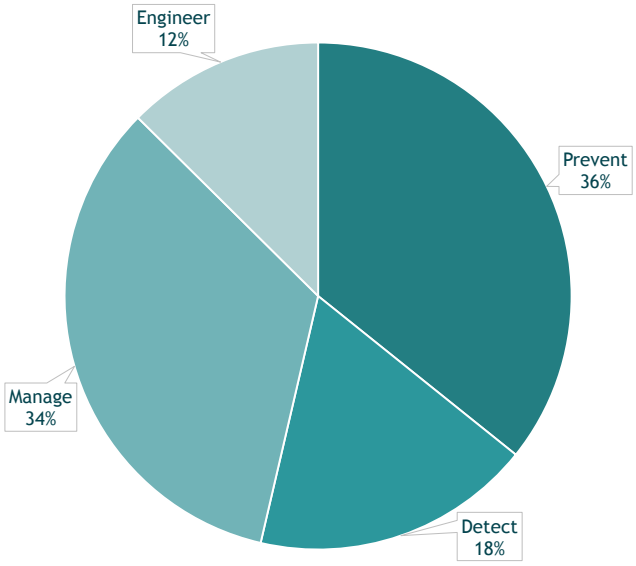


POC 2
% of project applications awarded by industry sector

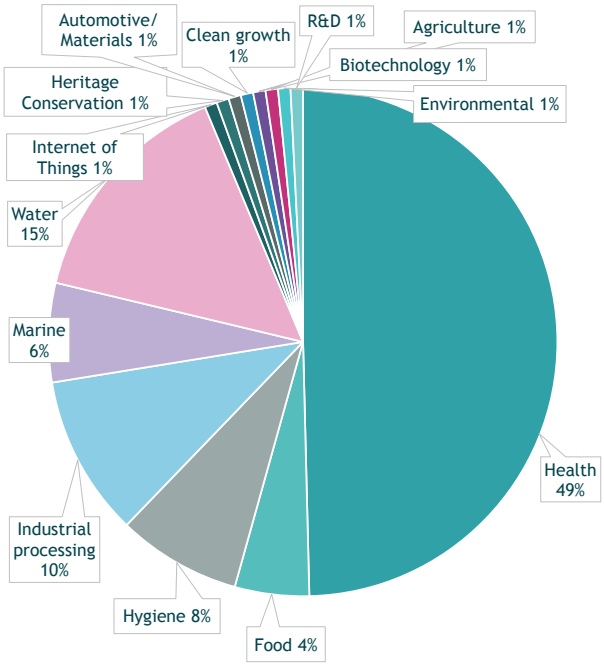
NBIC POC PROJECT PORTFOLIO



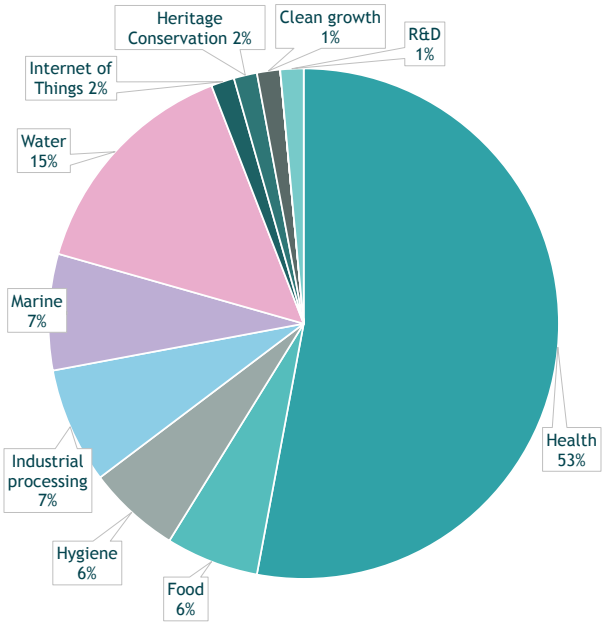
Portfolio
% of project applications by interventional theme (PDME)



Portfolio
% of project applications awarded by interventional theme (PDME)



Portfolio
% of project applications by industry sector



Portfolio
% of project applications awarded by industry sector

We will run Proof of Concept project calls in 2020 and 2021 and will consider later TRL levels as our portfolio and the needs of the community mature.

Additionally, with the £1m in-kind investment from the Hartree Centre (Science and Technologies Facilities Council (STFC)), we will run a funding call for collaborative projects requiring data analysis and high-performance computing power (HPC) power. With our Academic and Industry Partners, we are jointly establishing a consolidated and shared view of the key industrial biofilm challenges along with the status of the science in terms of emergence of possible solutions.

In addition to deepening our understanding via direct contacts with researchers and practitioners, we have followed two key work streams:

Workshops

We have run two NBIC workshops, on Biofilm Detection (Birmingham, October 2018) and Biofilm Engineering (Edinburgh, April 2019) with attendance from 80 and 90 Industry and Academic Partners (approximately 40:60 balance). There was wide sectorial representation at each workshop, from human and animal health to food, water, marine and engineering. The sessions were industry problem-led, leading to outputs which defined the key challenges in the sector. We have widely disseminated the workshop reports and in several cases, relationships developed at the workshops have led to POC project submissions.

We are currently planning similar workshops on Managing (2019) and Preventing (2020) biofilms, in addition to developing workshops on marine biofouling with Plymouth Marine Labs; on the gut microbiome with the Quadram Institute; on the skin microbiome with the KTN; and on Microbes and Metal with the Center for Biofilm Engineering (Montana State University, US).

Building a shared language for dialogue

We have devoted time across our Industry and Academic community to understand the language and terminology of biofilms, and this has been captured as an ontology on the platform MindManager, available on our website. This was developed in consultation with 80 UK researchers (in industry and RIs) to document how they talk about and describe biofilm research, problems and opportunities.

Communications and Outreach

RAISING AWARENESS OF BIOFILMS IN THE UK AND BEYOND

Public Engagement and Outreach

Public Engagement (dialoguing with the public in a meaningful way) and Outreach (raising aspirations of children) about 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. NBIC has a Public Engagement (PE) and Outreach Officer, and a Committee in place to support these activities.

NBIC have conducted a wide range of activities across the UK (from biofilm dances to biofilms in a train station), and are planning more local and national events, including bidding for the Royal Society Summer Exhibition in 2020.

We are also developing educational resources to be made available on our website for wider use, and offer grants up to £500 and the support of the NBIC PE and Outreach Officer for any biofilm public engagement or outreach project. Any NBIC affiliated individual/groups can apply for this funding online.

Communications

Through our marketing and communication activities we have brought together NBIC members and the wider biofilm community.

We've refreshed the NBIC brand, grown by 200% on our social media channels, and currently send two regular monthly email newsletters highlighting the latest news and relevant opportunities in the sector to internal and external audiences. These have an average of a 40-45% open-rate and 10% click-through rate – demonstrating a high level of engagement and the value we provide.

Case Study

CONTROLLING LISTERIA IN FOOD PRODUCTION FACILITIES

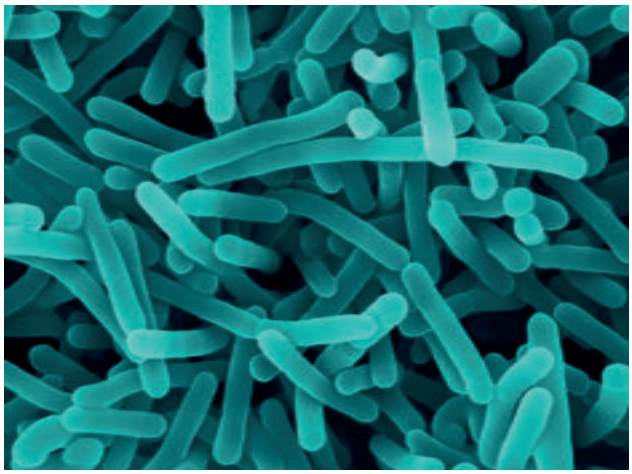
Helping industry find academic partners to solve unmet needs

We regularly help our Industrial Partners to find suitable Academic Partners within NBIC to collaborate on solving their applied problem areas. One such partner is the Chilled Food Association (CFA) and we worked with them to create a problem statement around one of these relating to the use of safe visible light for biofilm control and disinfection in the chilled food industry. We sent this statement out to our Academic members.

Ken Johnston, a Consultant and Advisor to The Chilled Food Association, said: "The CFA is constantly looking for new ways to enhance the efficiency of food manufacture. Listeria monocytogenes is an organism of particular concern to us because of its public health importance and its toughness in biofilm environments. Through NBIC's network we found a suitable partner, the Quadram Institute, where Dr Mark Webber leads the antimicrobial resistance group, to help us evaluate novel approaches to the control of listeria."

Dr Webber says: "We have been close to NBIC since day one and when we saw the problem statement, were able to respond immediately as we have experience in this area and met with Ken to identify the work needed to address this problem. We submitted an application to NBIC's first Proof of Concept project call for a 6-month project and were delighted to be successful."

The CFA/Quadram Proof of Concept project has recently started and the practical work is led by Dr Chloe Hutchins. The project demonstrates how NBIC can be engaged in understanding and disseminating unmet needs, finding partners and then enabling translation.



SEM of Listeria monocytogenes, magnification: x 3,000.

Dr Webber's research group studies the molecular mechanisms of antibiotic resistance with a focus on understanding how, where, when and why bacteria evolve antibiotic resistance. He is particularly interested in bacterial biofilms and is investigating how bacteria adapt to antimicrobial pressure within a biofilm. Dr Webber has published over 80 articles relating to antimicrobials and acts as an expert advisor on antimicrobial resistance for the WHO. Dr Hutchins is currently working as a Postdoctoral Researcher at the Quadram Institute.

The Chilled Food Association is a trade association representing chilled prepared food producers supplying the UK's ~£13bn market, primarily through major retailers. CFA develops best practice guidance and standards on food production from farm to fork, sustainability and skills, supports and monitors research, and represents the sector in regulatory affairs and the media.

Dr Mark Webber

Dr Chloe Hutchins

Project Summary

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 could be an additional operator-safe disinfection measure, however its impact against listeria in factory conditions is unknown.

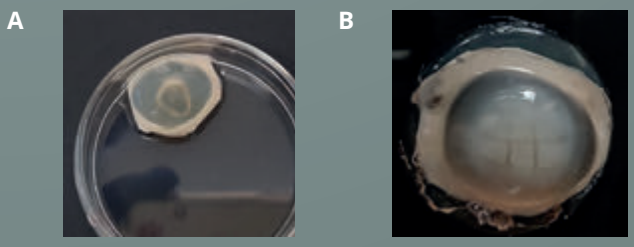
Case Study

FINDING TREATMENTS FOR EYE INFECTIONS

Helping to support biofilm models to assess novel interventions

Antibiotic-resistant bacterial and fungal eye infections pose a significant threat resulting in vision impairment or even blindness particularly in lower- to middle-income countries. In established eye infections, biofilms often form and are difficult to treat with conventional antibiotics, a problem exacerbated by the rise of antimicrobial resistance in a wide range of organisms. Biofilms are responsible for several chronic, ocular infections in man e.g. bacterial keratitis and lacrimal/periorbital infections.

In the Sheffield Collaboratorium for Antimicrobial Resistance and Biofilms (SCARAB), an Innovate UK-funded research facility within the University of Sheffield, a porcine corneal explant culture system has been developed for longer-term bacterial and fungal infection that allows us to study the initial, planktonic infection as well as microcolony and mature biofilm formation. Over the longer time-periods, the microbes cause disruption of the epithelium and penetrate into deeper layers of the corneum resulting in ulceration and eventual tissue destruction (see figure below).



Corneal explant biofilm model. A) Representative image of an uninfected corneum maintained in the laboratory for 5 days. B) Representative image of a corneum infected with Pseudomonas aeruginosa.

NBIC funded a study in SCARAB to examine the effectiveness of novel antimicrobial-drugs (Tecrea Ltd and Blueberry Therapeutics), against both clinically relevant bacterial and fungal species in the explant. We are exploiting the explant model of biofilm formation to determine the efficacy of a series of nanoparticle formulations of antimicrobial drugs on developing and mature biofilms. Such formulations are predicted to enhance efficacy through the disruption of biofilms and improved drug retention in the eye. The outcomes of the study will enable the identification of a core set of formulations that will be taken forward for commercialisation.

Project Summary

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.

Professor Peter Monk

Principal Investigator

Professor Peter Monk is a Professor of Immunology based at the Department of Immunology at the University of Sheffield. His research interest is in modelling infection in human tissues.

Dr Esther Karunakaran

Co-Investigator

Dr Esther Karunakaran is a Lecturer in the Department of Chemical and Biological Engineering at the University of Sheffield. Her research interests revolve around the investigation and application of biofilms in bio-processing.

Case Study

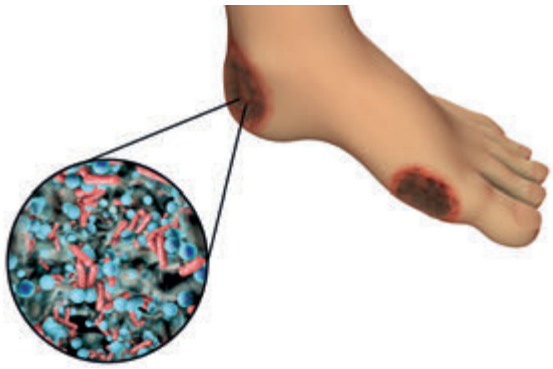
DIAGNOSING INFECTION IN CHRONIC WOUNDS

Assisting the academic community to find the right industrial partner

We regularly help our academic community to find suitable industrial partners to collaborate with on progressing a real-world application of their technology or knowledge either via our workshops, making direct contact or by targeted partner searches. One such partner is Dr Sourav Ghosh (Loughborough University). Loughborough were planning on joining NBIC and as part of our discussions described a diagnostic technology for which they needed a partner. We worked with Dr Ghosh on framing the offering to potentially solve a critical unmet need and then circulating it to our industrial community.

The technology is a simple portable test that can perform within 30-45 minutes a single-step detection of whole bacteria and their antibiotic susceptibility. This could for example be in a chronic wound. Dr Ghosh said: "We were looking to find a company who could validate this as an unmet need and with whom we could work together to further develop the test into a useful format. The search that NBIC did for us led to some useful contacts. Ultimately we ended up putting in a POC application with a global leader in this field (Smith & Nephew) which was successful!"

Smith & Nephew is a leading medical technology company, operating in around 100 countries globally. Dr Iain Webster, Research & Innovation Director at Smith & Nephew said: "Improperly diagnosed wounds place a heavy burden on global healthcare systems. In the UK, approximately 30% of the wounds are not definitively diagnosed. The economic cost of this to the wider society is comparable with that of managing



Diabetic foot infection. Computer illustration showing the common location of ulcers in diabetic foot infection and close-up view of bacteria which cause infection of diabetic foot ulcers.

obesity, which was £27 billion in 2014-15. This proposed rapid, definitive and cost-effective diagnostic test for wound infections could transform the therapy pathways for this problem." The streamlined partner search and NBIC application process allowed both parties to work together to efficiently formulate and submit a POC application. The whole process - from circulating the offering to the community to submitting the NBIC POC application as an industry sponsored collaborative piece of work - only took three weeks. The project will start once the contracting phase is completed.

Project Summary

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.

Dr Sourav Ghosh

Dr Sourav Ghosh is a mechanical engineer by background, and specialises in applying engineering and physical science principles to solve biosensing problems. The key areas of application include clinical diagnostics, biomanufacturing and environmental monitoring. Prior to his doctoral research, he worked in industry: heavy engineering, energy and utilities sectors for five years. He completed his postgraduate studies in biomedical engineering at the University of Oxford.

International Engagement

FACILITATING INTERNATIONAL ENGAGEMENT AND COLLABORATION IN BIOFILMS

UK-Singapore partnership on biofilms

The UK Science and Innovation Network (SIN) works on behalf of UK Research and Innovation (UKRI) to identify and facilitate new research collaborations across the breadth of the UK's research base. They supported NBIC's interactions with Singapore researchers – NBIC visited Singapore in February 2018 to participate in a joint workshop with the Singapore Centre for Environmental Life Sciences Engineering (SCELSE), where complementary areas for strategic R&D collaboration were identified.

A year on, in February 2019, SIN supported a second visit by NBIC which led to the signing of two Memoranda of Understanding (MOU) with SCELSE and the Singapore National Biofilm Centre (SNBC). The NBIC leadership team and three Industry Partners (Bioquell, Fourth State Medicine and Varicon Aqua) showcased the UK's global leadership in biofilms and the investment offer in Health and Life Sciences by participating in a biofilms research and industry symposium at the UK-Singapore Investor Club, which SIN organised with the Department for International Trade (DIT). Finally, NBIC took part in a launch ceremony – 'When Microbes Mean Business' – where NBIC signed two MOUs with SCELSE and SNBC, paving the way for a truly academic-industry partnership that will cement the UK and Singapore as global leaders in biofilms research and innovation. These agreements will facilitate joint R&D programmes, sharing of knowledge and expertise, researcher exchanges and trade between the UK and Singapore, strengthening our global position in biofilm research and innovation.

Developing a global network

NBIC signed a MOU with the Center for Biofilm Engineering (CBE) at Montana State University (US) in October 2018, and are successfully continuing to work together to develop projects and exchanges. Further to this, NBIC have been awarded an International Workshop grant (£10k) to bring the two groups together later in 2019 to identify fundamental challenges in the field of micro-metal interactions.

In continuing to build relationships internationally, NBIC also signed a MOU with Stellenbosch University (South Africa). Going ahead, NBIC will establish collaborative projects and promote academic exchanges. NBIC also have long standing collaborations with the Costerton Biofilm Centre in Copenhagen. NBIC are currently working on formalising a program of research and student exchange.

Operational Team

EXECUTING THE NBIC STRATEGY

Dr Mark Richardson - CEO

Mark joined NBIC on its formation in December 2017. Mark worked for over 30 years in R&D in the Medical Device Industry, leading projects and global teams. He led the Global Innovation team for Smith & Nephew Wound Management from 2000-2002, and then formed and led their approaches to Open Innovation, including engaging with Innovation Knowledge Centres in the UK.

Mark gained his degree in Microbiology at the University of Leeds followed by an MSc and PhD in Biochemistry from the University of Birmingham. He also has an MBA from the Open University.

Dr Jo Slater-Jefferies – Operations Director

Jo joined NBIC in April 2018 and is also a Director and Trustee of the Asthma, Allergy and Inflammation Research (AAIR) charity. 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, and 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 a MBA, and in 2017 became a Chartered Manager at the Chartered Management Institute.

William Green – Senior Innovation Consultant

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.

Dr Katerina Steventon – Senior Innovation Consultant

Katerina is a healthcare specialist with substantial experience of working at the clinical, commercial and research interface. She holds a MSc in Clinical Biochemistry, a PhD in Transdermal Absorptions and over 20 years of global work experience in the personal care and wound care industry. Katerina has an in-depth knowledge of skin biology in both its healthy and diseased states. The strengths Katerina brings to NBIC comprise a comprehensive understanding of the industry and academia, commercialisation of research in a spectrum of healthcare areas and an experience of running an innovation consultancy with a focus on functional skincare.

Jing Lin – Project Manager

Jing has both project management and programme management experience throughout her career in a multi-national enterprise, carbon trading consulting firm, lobbying association, and research institutions. She holds a MSc in Finance and Economics from the University of Southampton. Jing has also obtained a certificate in MSP Managing Successful Programmes in her own time.

Razwana Quadir – Communications Manager

Razwana has over 5 years' experience in marketing and digital communications across both the private and public sector. She holds a BA Honours/MA in Social and Political Sciences and Management Studies from the University of Cambridge, and a CIM Diploma in Professional Marketing.

She was responsible for managing the University of Southampton's global undergraduate campaigns and digital activities between 2015-2018, before taking a break to pursue freelancing and writing projects. Razwana has a strong interest in digital marketing, strategy, brand and social media, and joined NBIC in October 2018 to lead on the marketing and communications strategy and its implementation.

Dr Charlotte May - Research Development Officer

Charlotte is based at the School of Life Sciences at the University of Nottingham and has held a variety of roles in the Higher Education sector. She gained her BA, MA and PhD from the University of Nottingham. From her experience with working in the heritage sector and science communication, Charlotte is particularly passionate about public engagement and enriching the experience of postgraduate researchers.

Dr Jean-Christophe (JC) Denis – Public Engagement and Outreach Officer

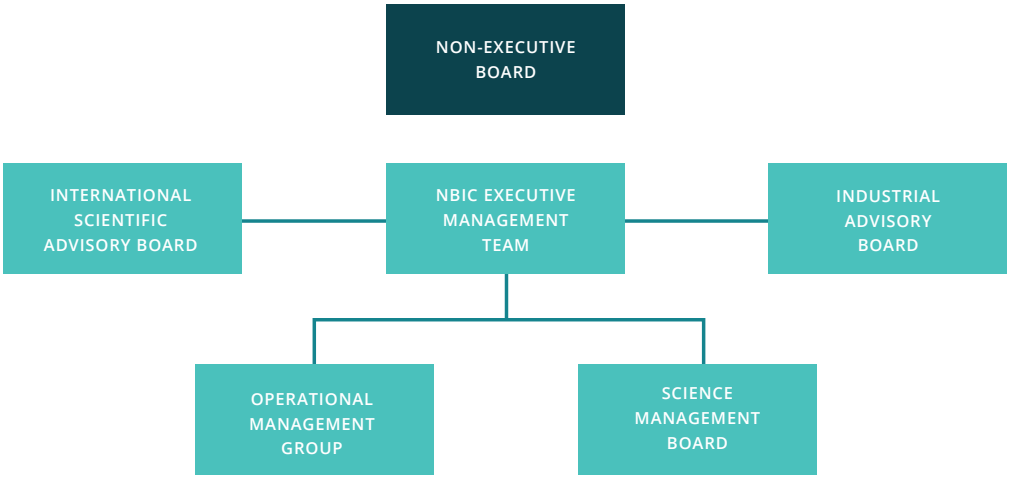
After an academic research career (Engineering studies at Supelec in France, followed by a PhD and Postdoc in Chemical Physics at Heriot-Watt University in Edinburgh), JC followed his passion and moved to the position of Outreach and Public Engagement Officer in 2017. JC first got involved in outreach 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.

Vicky Randall - Administrator

Vicky started her career as a would-be scientist, following on from a BSc Biochemistry with a stint as a PhD student. Passion for science and research still intact, and driven by the motivation to support and organise, Vicky joined NBIC in April 2019 to support the effective running of the Operational Team. Having relocated to Southampton in 2013, she now considers this to be her long-term home with the next goal to gain her full motorbike licence before the year is out.

Governance Structure

LEAD AND ADVISE NBIC STRATEGY



Non-Executive Board (NEB)

Ceri Williams (Chair), Hilary Lappin-Scott, Laura Pritchard, Gordon Ford, Neil Parry and Fiona Lettice. NBIC has established a Non-Executive Board of external members, which includes representatives from NBIC's funders, International Science Advisory Board (ISAB) and Industrial Advisory Board (IAB). The NEB's role is to guide the strategic direction and development of NBIC, as well as having oversight of the operation and management of NBIC, and implementation of the Consortium Agreement. All Board members are bound by Terms of Reference, which outlines their roles and responsibilities.

Executive Management Team (EMT)

Mark Richardson (Chair), Jeremy Webb, Miguel Cámara, Cait MacPhee, Rasmita Raval and Jo Slater-Jefferies. The EMT's role is to have executive and overall management responsibility of NBIC. The Terms of Reference outlines their roles and responsibilities, which include the delivery of NBIC's Mission and Vision, and in consultation with ISAB, the IAB and the Scientific Management Board (SMB), approve the Scientific Strategy of NBIC.

Science Management Board (SMB)

Jeremy Webb (Chair), Miguel Cámara, Cait MacPhee, Rasmita Raval and Jo Slater-Jefferies. Other Scientists from NBIC Partner Institutions may be co-opted to the SMB for a period specified by the SMB or asked to join single SMB meetings. The SMB's role is to make recommendations to the EMT on the scientific direction together with NBIC's strategy and the annual Programme Proposal (projects under the Strategic Themes of Prevent, Detect, Manage and Engineer).

Industry Advisory Board (IAB)

Neil Parry (Chair - Unilever), Stewart McKinlay (Smith & Nephew), David Bradshaw (GSK), Ken Johnston (CFA), Steven Percival (5D Health Protection Group Ltd), Ian Archer (IBIOIC) and Kirsty Salmon (BP). Business leaders from multinational companies and SMEs have been recruited to the IAB on the basis of their experience and knowledge of the biofilms industry across the identified strategic sectors. The Terms of Reference outlines their roles and responsibilities, which include advising the EMT on the development of NBIC, the industrial engagement strategy for NBIC, NBIC funding calls and the commercial exploitation of the results of the research conducted through NBIC. Members of the IAB have been asked to enter into an appropriate written confidentiality agreement to protect the confidentiality of the information disclosed to them in respect of NBIC.

International Scientific Advisory Board (ISAB)

Hilary Lappin-Scott (Chair), Inigo Lasa, Tom Coenye, Marie-Claire Pradier and Mark Van Loosdrecht. Scientific leaders from international institutions have been brought together to test 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 EMT on the opportunities for exploitation of the scientific profile and advances made by the centre.

Operational Management Group (OMG)

Jo Slater-Jefferies (Chair), Mark Richardson, Jing Lin, Razwana Quadir, Katerina Steventon, William Green, Vicky Randall, Charlotte May and Jean-Christophe Denis will work together with functional representatives of the core Academic Partners. The OMG ensure the effective management of NBIC and work closely with the Parties' respective financial, contract, intellectual property management, and technology transfer functions to streamline the initiation of projects and any commercialisation activity. The Terms of Reference outlines their roles and responsibilities. They support the EMT and SMB in the delivery of NBIC's strategy and establish the necessary operational procedures to ensure its effective execution.

The Public Engagement and Outreach Committee are also part of OMG, and involve representatives from the four core lead universities. The team is comprised of: Jean-Christophe Denis (Chair), Susana Direito, Jo Slater-Jefferies, Joe Parker, Jing Ling, Razwana Quadir, Charlotte May, Shaun Robertson, Sean Goodman and Fiona McBride.

Proof of Concept 1

AWARDED OCTOBER 2018

PROJECT TITLE	PROJECT SUMMARY	UNIVERSITY/ RESEARCH INSTITUTION	INDUSTRY PARTNER/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

PROJECT TITLE	PROJECT SUMMARY	UNIVERSITY/ RESEARCH INSTITUTION	INDUSTRY PARTNER/S
Development and evaluation of a dual function dressing to combat biofilm infection and exudatein 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
The effect of low frequency ultra-sound 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)
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, 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 in 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

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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 bio-film-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
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

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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 the 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

Proof of Concept 2

AWARDED JULY 2019

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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.	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, Water Industry Process and 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

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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 (LMIC) 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
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 and (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 we are using nanotechnology to disrupt these films to expose the organisms to treatment.	University of Bradford	5D Health Protection Group Ltd
The effect of electrospun nanofibre diameter and conditioning film on controlling active biofilm formation in wound dressings	Biofilm formation leads to significant failure of wound dressings, due to poor nanofiber design. This prolongs healing and increases the risks of invasive disease. In collaboration with Hybrisan, we will fabricate nanofibers of different diameters changing their morphology (size/shape) improving antimicrobial properties and colonisation resistance of wound dressings.	Swansea University	Hybrisan
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

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Impact of ozone application on Listeria monocytogenes biofilms on drain covers under food processing-relevant conditions	Listeria monocytogenes is a food-borne bacterium that can cause serious and sometimes fatal disease in humans. Food factory drains can harbour listeria biofilms, hence the need for thorough cleaning techniques. This project will test the extent of reduction of listeria by Anacail's high-dose ozone in factory-relevant conditions on drain covers.	James Hutton Institute	Anacail Ltd
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, which will 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
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	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

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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 patient's 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 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

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