Annual Report 2020

HARNESSING THE UK’S ACADEMIC AND INDUSTRIAL STRENGTH IN BIOFILMS
The National Biofilms Innovation Centre (NBIC) is still a relatively young organisation but I am proud that we have achieved so much since our formation in late 2017. I reflect that our USA partner group, the Center for Biofilm Engineering (CBE) in Montana, is celebrating its 30th year! Our ambition is to be equally enduring. We were formed to support and connect the biofilm community across industry and academia in the UK. In the challenging circumstances we currently face globally, it’s clear that never has the importance of innovation and science been so critical.

From day one it has been our intent to behave in a national, inclusive and transparent way to benefit our community. Our primary focus as we mature is to harness and translate the capability, knowledge and technology in the prevention, detection, management and engineering of biofilms across the UK. We have also worked to connect ourselves internationally, including forming alliances with the CBE in the USA and the Singapore National Biofilms Consortium (SNBC) so that we are able to facilitate collaboration between our academic and industrial partners beyond the UK.

I am delighted that our membership now includes 52 UK research institutions and that these academic partners share our desire to collaborate and connect with the (approximately) 250 companies we have talked to and visited across a range of sectors. We aim to connect unmet industrial and commercial needs and possible scientific or technological solutions that may exist in our partners. We do this both through personal introduction, and by sharing needs and solutions across our network.

We endeavour to build on three key pillars that our funders (Biotechnology and Biological Sciences Research Council, Innovate UK and the Hartree Centre) have asked us to establish, namely:

**RESEARCH**

Our funding has allowed us to recruit 12 Interdisciplinary Research Fellows (IRFs) across our founding core four universities who are now all actively engaged in a mixture of underpinning research and collaborating with industry.

**INNOVATION**

We have run three Proof of Concept (POC) calls, receiving 144 applications from companies and research partners, from which we have awarded 65 POC projects, representing a £3.6m investment from NBIC and a total value of £5.4m. In addition, we have run 4 themed workshops resulting in policy papers and multiple industry/academic collaborations and connections. All of this is supported by a core NBIC team including three field-based sector specialists who visit and connect our partner companies and research institutions.

**TRAINING**

We have a cohort of 9 PhD students across our four core universities for whom we are running a core Doctoral Training Programme, which is also available to our IRF group. We are proud to be running our first entrepreneurial training and support programme in conjunction with Alderley Park.

As we enter our third full year, I see that everyone involved in NBIC across the UK is as committed as ever to our vision of delivering both breakthrough science and technologies to control and exploit biofilms, and to inspire the next generation of research leaders and entrepreneurs.

- **MARK RICHARDSON, CEO, SEPTEMBER 2020**
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 (Edinburgh, Liverpool, Nottingham and Southampton) and a partnership that has now expanded to include 52 associate research institutions (RIs), support from a growing base of more than 250 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

DECEMBER 2017, NBIC ESTABLISHED
£3m investment from the Biotechnology and Biological Sciences Research Council (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.

MAY 2018, PARTNER MEETING & 1ST WAVE ACCESSION
Partner meeting in York brought together representatives from research institutions interested in participating in NBIC. 72 new research institutions join the NBIC consortium bringing us to a total of 117.

JUNE 2018, 1ST WAVE ACCESSION
Welcome 15 new research institutions to the NBIC consortium, taking our total to 31 institutions.

MAY 2019, 2ND WAVE ACCESSION
Accession of 25 new research institutions, bringing our total to 56.

SEPTEMBER 2019, 3RD WAVE ACCESSION
14 new research institutions joined the NBIC consortium bringing us to a total of 70.

JUNE 2020, LAUNCH OF #BIOFILMMAKERS CAMPAIGN
NBIC announced the launch of their biofilm awareness campaign. Through a blend of content, events and outreach activities #BiofilmMakers works to raise awareness of NBIC’s work and its research, and the many societal and economic impacts of biofilms. The campaign includes the introduction of the UK’s first BiofilmBite, to be held in July 2021 to coincide with an NBC event.

FEBRUARY 2020, BIOFILM WORKSHOP
NBIC attended and launched a #ktn workshop on identifying and promoting industrial challenges and solutions in controlling and exploiting biofilms.

AUGUST 2020, LAUNCH OF 2020 DOCTORAL COLLEGE TRAINING CONCEPT
Launched Call for projects building biofilms launched in the UK - open to all members of the NBIC consortium and industry collaborators.

SEPTEMBER 2020, FIRST NBIC WORKSHOP & THEORY OF CHANGE ESTABLISHED
First cross-sectorial workshop on one of NBIC’s key strategic themes, biofilms was held in Birmingham, with 70 delegates from academia and industry coming together to discuss unmet needs. Our aim for the next 5 years was established in a comprehensive Theory of Change model, with the ultimate long-term goal of increasing the UK economy.

NOVEMBER 2020, WIN BBSRC FDTA (FLEXIBLE TALENT MOBILITY ACCOUNTABILITY) AWARD
Won funding to facilitate PhD and Research Fellow mobility between academia and industry.

FEBRUARY 2020, FORMATION OF INTERNATIONAL STANDARDS TASK GROUP
To address the growing influence and popularity of biofilm and microbiome technologies an international task group was formed. The first meeting of the task group was held by Zoom in the USA, with delegates from SCELSE, the Centre for Biofilms Engineering (CBE) USA, the National Biofilms Innovation Centre (NBIC) UK, and the Singapore National Biofilms Consortium (SNBC), led by SCELSE, to further commercial opportunities and drive technological advancements.

FEBRUARY 2020, 3RD WAVE ACCESSION
7 new research institutions joined the NBIC consortium, bringing us to a total of 72.

NOVEMBER 2019, SOFTWARE SUSTAINABILITY WORKSHOP
The Software Sustainability Workshop brought together 20 attendees from seven UK universities, plus Univerisity at the Midlands in the heart of Birmingham. We ran the event alongside the Software Sustainability Institute in a bid to raise awareness of the need for sustainability in software, particularly when it comes to the potential risk to software reproducibility.

NOVEMBER 2019, SOFTWARE SUSTAINABILITY WORKSHOP
Workshop on Biofilm Management was held in Nottingham. This workshop was about exploring current funding needs in the field of Biofilm Management. NBIC partnered organisations shared their unmet needs and the £3.5m awarded to UK and industry in groups to discuss the key challenges and ways to overcome them.

MARCH 2019, MOU SIGNED WITH BIOFILMMANAGEMENT AWARDS UK
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, in further commercial opportunities and drive technological advancements.

SEPTEMBER 2019, CALL LAUNCHED
NBIC awarded a second round of funding from BBSRC to support our current Flexible Talent Mobility Award (FTMA) Account, with a call opening in September 2020, which aims to fund innovation placements and fellowships, perspectives and knowledge, skills and expertise between the academic and industrial sectors.

FEBRUARY 2020, FLEXIBLE TALENT MOBILITY AWARD
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FEBRUARY 2020, 4TH WAVE ACCESSION
7 new research institutions joined the NBIC consortium, bringing us to a total of 72.

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

MARCH 2019, SECOND PROOF OF CONCEPT 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.

FEBRUARY 2020, 4TH WAVE ACCESSION
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MAY 2020, THIRD PROOF OF CONCEPT CALL PROJECTS AWARDED
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FEBRUARY 2020, 3RD WAVE ACCESSION
Accession of 25 new research institutions, bringing our total to 56.

APRIL 2020, SECOND NBIC WORKSHOP HELD, SECOND PROOF OF CONCEPT CALL LAUNCHED & RECEIVED
Our workshop on Biofilm Management was held in Edinburgh, bringing together over 85 delegates from academia and industry to discuss and identify unmet needs and facilitate collaborations.

Our second Proof of Concept call was launched - open to all members of the NBIC consortium and industry collaborators. We also awarded £13k by NBIC, to host an internal symposium on ‘Microbes and Metals’.

MARCH 2019, INTERNATIONAL MANAGEMENT WORKSHOP HELD, SECOND NBIC PROOF OF CONCEPT CALL LAUNCHED
Our workshop on Biofilm Management was held in Nottingham. This was the first meeting we attended as a full NBIC team with our new brand. It was a chance to meet our industry partners and make new contacts. We also had the honour to present at the final session.

MARCH 2019, INTERNATIONAL PARTNERING AWARD
Selected as the winner of the Biofilms Innovation and Engineering (SCSEL) competition an international group was formed. The first meeting of the task group was held by Zoom in the USA, with delegates from SCELSE, the Centre for Biofilms Engineering (CBE) USA, the National Biofilms Innovation Centre (NBIC) UK, and the Singapore National Biofilms Consortium (SNBC), along with representatives from regulatory bodies and agencies across the US and the European Union.

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SEPTEMBER 2019, NBIC ATTEND EUROBIOFILMS
NBIC attended and launched a #ktn workshop on identifying and promoting industrial challenges and solutions in controlling and exploiting biofilms.

SEPTEMBER 2019, SUCCESSFUL 2 YEAR Funding REVIEW
As part of the condition of the NBIC IRC award, an external panel reviewed the progress of NBIC against their Vision, Mission and Key Performance Indicators. The panel deemed that NBIC was making good progress, the highest outcome that could be expected.

FEBRUARY 2020, BIOFILM MANAGEMENT WORKSHOP
Our workshop on Microbe-Metal Interactions was held in London. This workshop brought together key complementary academic expertise and thought leadership from industry in biofilms, biocorrosion, metal surfaces and bionanotechnology across the life and physical sciences and engineering domains within NBIC, CBE and internationally in order to identify the key research gaps and research challenges for future projects and research collaboration.

NOVEMBER 2019, MICROBE-METAL INTERACTIONS
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DECEMBER 2019, >60 BUSINESSES AND INDUSTRY COLLABORATORS
From large multinationals to SMEs, NBIC continues to grow its presence in control- to-critical and expert biofilms by bringing research and industry together.

OCTOBER 2018, FUNDING OF 23 NEW PROJECTS & GONGS INTERNATIONAL
NBIC invested £1.4m - averaging £64k per project - to 25 new projects from the first POC call - the total project value, with company investment, amounted to approx. £2.7m. NBIC signed the US National Academy of Sciences for Microbiology in Washington, and signed the Center for Biofilm Engineering (CBE) at Montana State University - where a Memorandum of Understanding (MOU) will work together, partake in student knowledge transfer.

我们的成就
自2017年

2017
2018
2019
2020
NOW, Over 150 industry partners and growing.
# Building an International Community

## OF BIOFILM RESEARCHERS

### Our Key Objectives

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

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## Theory of Change

### NBIC STRATEGY & GOALS

<table>
<thead>
<tr>
<th>FINAL GOAL: MEASURABLE IMPACT ON THE UK ECONOMY</th>
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<tbody>
<tr>
<td>IMPACT &amp; BENEFIT</td>
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<tr>
<td>• Strategic national infrastructure developed &amp;</td>
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<td>well-established innovative knowledge centres (IK)</td>
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<td>• Industry and学术oval value created</td>
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<td>• Raised public awareness of biofilms and implications</td>
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<tr>
<td>• Eco-friendly, sustainable and economically</td>
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<td>• ROI - created more value</td>
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<tr>
<td>SUSTAINABILITY &amp; LEGACY</td>
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<tr>
<td>• Long-term environmental impact</td>
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<tr>
<td>• Continued funding from investors</td>
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<td>• Brand recognition</td>
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<tr>
<td>• Continuous development from collaborations</td>
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### OUR APPROACH

At NBIC we believe in a forward-thinking, interdisciplinary approach, underpinned by excellence and our values: collaborative, transparent, innovative, flexible, responsive and responsible. Through collaboration we advance research, training future academics and innovators. Through translating research and innovation, we work to build the environment and opportunities for innovation and economic benefit. To do this, we will strengthen and develop our own research and innovation capacity, work with existing and new industry partners, establish and support international collaborations, develop new technologies and commercialise them to create a positive impact on society.

### INTERMEDIATE OUTCOMES OVER INITIAL 5 YEARS

- **Economic and societal benefit:** SCIENCE, COMMERCIAL, ECONOMIC, SOCIETAL AND ENVIRONMENTAL BENEFIT CREATED
- **Sciences:** SCIENTIFICALLY AGILE, INDUSTRY-READY LEADERS
- **Research and innovation capacity:** INCREASINGLY RESPONSIVE TO SECTORAL CHANGES WITH BREAKTHROUGH INNOVATIONS
- **Impact & benefit:** SCIENTIFIC, COMMERCIAL, ECONOMIC, SOCIETAL AND ENVIRONMENTAL BENEFIT CREATED
- **INTERDISCIPLINARY RESEARCH**
  - Establishing a pan-UK research strategy aligned with UKRI and industry strategies
  - Interdisciplinary working across research and sectors
- **EDUCATIONAL ACTIVITIES**
  - Achieving a critical mass and infrastructure capability
  - Deepening scientific understanding of the generation, detection, management and engineering of biofilms
- **INTERMEDIATE OUTCOMES OVER INITIAL 5 YEARS**
  - Economic and societal benefit created
  - Interdisciplinary working across research and sectors
  - Achieving a critical mass and infrastructure capability
  - Deepening scientific understanding of the generation, detection, management and engineering of biofilms
  - Interdisciplinary training through dedicated MSc, MRes and PhD programmes to develop the next generation of scientifically agile, industry-ready leaders

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### SHORT TERM

- **CONCISE OUTPUTS OVER INITIAL 2 YEARS**
  - NBIC roadmap for biofilms established
  - Increasingly responsive to sectoral changes with breakthrough innovations
  - Responsible innovation: Innovations: Publications, IPs/patents, citations, facilities & services
  - SCIENTIFIC, COMMERCIAL, ECONOMIC, SOCIETAL AND ENVIRONMENTAL BENEFIT CREATED
  - INCREASINGLY RESPONSIVE TO SECTORAL CHANGES WITH BREAKTHROUGH INNOVATIONS

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### MEDIUM TERM

- **DIRECT OUTPUTS**
  - Publications, conferences, facilities/services
  - Innovations: Commercial spin-off, industry partnerships
  - NBIC roadmap for biofilms established

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### LONG TERM

- **SUSTAINABILITY & LEGACY**
  - Successful engagement with leading international researchers
  - Brand recognition
  - Continuous development from collaborations

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**NBIC Strategy & Goals**

### LONG TERM

- **SUSTAINABILITY & LEGACY**
  - Successful engagement with leading international researchers
  - Brand recognition
  - Continuous development from collaborations

### MEDIUM TERM

- **DIRECT OUTPUTS**
  - Publications, conferences, facilities/services
  - Innovations: Commercial spin-off, industry partnerships
  - NBIC roadmap for biofilms established

### SHORT TERM

- **CONCISE OUTPUTS OVER INITIAL 2 YEARS**
  - NBIC roadmap for biofilms established
  - Increasingly responsive to sectoral changes with breakthrough innovations
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**Prevent**

- New science that show 2-4 TRL (Technology Readiness Level)

**Detect**

- Early investment in NBIC

**Manage**

- ANYTHING RESEARCHERS

**Engineer**

- Key institutional, national and international academic and industry partnerships

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**How we will deliver**

- **FUNDING**
  -  £26m investment in NBIC from UKRI and industry

- **KNOWLEDGE & EXPERTISE**
  - >100 researchers, including scientists, engineers, technologists, translators and clinicians

- **ASSETS & CAPABILITIES**
  - World-class strategic facilities: amongst others provided by university and industry partnerships with state-of-the-art research platforms such as Predictive Modelling, Next Generation Imaging & Sensing

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**Operational team**

- A dedicated and growing NBIC operational team providing leadership, management and support across partners and collaborators
Governance and Advisory Boards

Our governance and advisory boards provide NBIC with guidance and advice on the direction of the centre and challenge the team. It is through regular face-to-face or online meetings that our governance and advisory bodies help NBIC to set out strategic direction and foundation for our research and outreach activities.

Non-Executive Board (NEB)
Consisting of the Chair, Ceri Williams (University of Leeds), Kath Mackay (Brunwood SciTech, Alderley Park), Fiona Lettice (University of East Anglia), Gordon Ford (Innovate UK), Neil Parry (Unilever), Laura Pritchard (UKRI-BBSRC) and Hilary Lappin-Scott (Cardiff University).

NBIC has established a Non-Executive Board of external members, which includes representatives from the NBIC’s funders, International Science Advisory Board and Industrial Advisory Board. The Non-Executive Board’s role is to guide the strategic direction and development, as well as having oversight of the operation and management of NBIC and the implementation of the Consortium Agreement. All Board members are bound by Terms of Reference, which outlines their roles and responsibilities.

Industrial Advisory Board (IAB)
Consisting of the Chair, Neil Parry (Unilever), Stewart McKinlay (Smith & Nephews), David Bradshaw (GlaxoSmithKline), Kirsty Salmon (BP plc), Ken Johnston (Chilled Food Association), Steven Percival (SD Health Protection Group Ltd), Ian Archer (IBioIC) and Kevin Peel (Kohler).

Business leaders from multinational companies and SMEs have been recruited to the Industrial Advisory Board (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 Executive Management Team (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 Industrial Advisory Board (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)
Consisting of the Chair, Hilary Lappin-Scott (Cardiff University), Rikke Louise Meyer (Aarhus University, Denmark), Tom Coenye (Ghent University, Belgium), Claire-Marie Pradier (Centre National de la Recherche Scientifique, France), Mark Van Loosdrecht (Delft University of Technology, Netherlands), Iñigo Lasa (Public University of Navarre, Spain), Agneta Richter-Dahlfors (Karolinska Institutet and KTH Royal Institute of Technology, Sweden) and Lars Dietrich (Columbia University, USA).

Scientific leaders from international institutions have been brought together to evaluate and challenge the scientific strategy of NBIC and its delivery and implementation in the context of the international development of the field. They advise the EMT on the opportunities for exploitation of the scientific profile and advances made by the centre. All ISAB members are bound by Terms of Reference, which outlines their roles and responsibilities.
Our Research Strategy

WORLD CLASS FUNDAMENTAL SCIENCE

NBIC is addressing four strategic themes to 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 12 Interdisciplinary Research Fellows (IRFs) to support NBIC’s fundamental research and training strategy (60% time), and who also conduct focused 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.

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 – Edinburgh, Liverpool, Nottingham and Southampton – 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 biofilms 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 in Biofilms Innovation, Technology and Engineering (BITE) was established in early 2019. It is a world class integrated pipeline of interdisciplinary training, involving a partnership between the universities of Edinburgh, Liverpool, Nottingham and Southampton, alongside international institutes and industry partners. It is the UK’s first graduate training centre to address the skills and knowledge gap in the biofilm field. The first cohort of nine students started in October 2019.

The Doctoral Training Centre draws on academic supervisors from physical, mathematical, engineering, life and clinical sciences within the partner universities to provide a unique, multidisciplinary and inter-sectoral 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 core universities, the Doctoral Training Centre provides the synergy, critical mass, and the breadth and depth required to deliver an ambitious training programme in biofilm science, engineering and technology.

Areas of specialisms

- **University of Edinburgh**
  Soft and active matter biological physics; complex fluids and rheology; HPC modelling; biofilms architecture; Synthetic and Systems Biology.

- **University of Liverpool**
  Functional surfaces 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 Southampton**
  Microbial ecology and evolution; AMR; Hybrid biodevices; Bioenergy; Host-microbe Interactions; Bacterial signal transduction; Imaging and detection; Translational biology; Clinically relevant biofilms.

Training

**BUILDING ENTREPRENEURIAL SKILLS**

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

**Alderley Park Accelerator**

The on-site incubation and acceleration team specialises in the start-up and scale up of biotech and life science businesses by providing the programmes, networks and support required for success. NBIC have jointly run a pre accelerator programme for our community as a prelude to a full follow-on 8 week Accelerator programme for best performing pre-accelerator graduates selected in a competitive process.

**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.
Software Sustainability Institute

The 2019 NBIC workshop brought together 20 attendees from seven UK universities, plus Unilever, in a high-tech space at the Malmaison in the heart of Birmingham. We ran this event alongside the Software Sustainability Institute (SSI) in a bid to raise awareness of the need for sustainability in software, particularly when it comes to the potential risks to software reproducibility. This had become particularly apparent when reading the responses from the biofilm community to a BBRSC consultation on data intensive bioscience in the summer of 2019. Having discussed the responses to the consultation, we agreed to run a joint workshop to spread some best practice, and to help both organisations get an idea of how things stood in UK biofilms research and software.

The event was held on 28 November and involved four breakout sessions and short talks throughout the day. The sessions introduced participants to the idea of software sustainability, to how to achieve software that is accessible and reproducible, and to how software sustainability helps to drive data management, accessibility and reuse. Speakers took into account the broad range of experience in the room, with attendees ranging from microbiologists who work in Excel to physicists coding agent-based simulations in C. Breakout group responses were captured on flipcharts and on online forms. In some exercises the participants self-reflected on their own practice, and these thoughts were sent to them following the meeting.

It was a successful day for both NBIC and the Institute, and feedback from attendees was positive. Attendees came away with a range of techniques and best-practice tips to improve the sustainability of their research software. We are pleased to be planning further Data and Software Carpentry workshops in collaboration with the SSI, with an aim of supporting and developing skills and confidence to work with data.

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 benefit of the UK.

We aim to deeply understand unmet needs in our industrial partners’ contexts and markets. Through engagement, we then aim to demonstrate the ability of NBIC research partners to address these needs, hence driving opportunities for industry and academic collaboration, investment and income. Our strategy is to match unmet industrial biofilm needs with possible solutions in order to prove we have the right to be an essential part of our industrial partners’ network or open innovation pipeline. We aim to listen, understand and explore needs and/or capabilities, and create and support connections. We find ways of progressing these connections, either through our own funding routes (Proof of Concept calls) or helping signpost to other opportunities. Each month we carry out partner searches where we aim to “match-make” an unmet need to an opportunity or solution (mainly company to research institutions) either via a personal contact through our innovation team or emails targeted to our wide network. In late 2020 we will launch our Open Innovation partnering platform, hosted by Innoget. Through our website, industry and academic partners will have exclusive access to directly post technology calls and technology offers, respond to other members’ postings and generate connections and collaboration opportunities. Partners will also have a choice to access Innoget’s Open Science and Innovation network of over a hundred thousand experts to further explore collaborations outside of NBIC’s partner consortium.

The four workshops we designed and led have seen over 350 attendees with an approximate mix of 50:50 academics and industry partners. These have all taken the format of exploring the key unmet needs from industry, looking at how the current state of the science and technology landscape could address these requirements and in doing so develop a shared understanding of the opportunities and challenges. The outputs from our four workshops are summarised below. Three of these represent 3/4 of our key international themes i.e. Detection, Management and Engineering of Biofilms. The last is a workshop we ran on Microbe–Metal interactions in conjunction with the Center for Biofilm Engineering. Our 4th theme of Biofilm Prevention will be the subject of a workshop in the next 12 months.
Key Findings
FROM NBIC WORKSHOPS

Biofilm Detection

Unmet needs:

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

Biofilm Management

Unmet needs:

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

Key areas of emerging science:

• Mechanisms and models of the metal-microbe interactions: In all fields of biofilm study including microbially influenced corrosion (MIC) there is a need for improved models that can truly recreate the real-world situation or model it in such a way that accurate predictions can be made and interventions realistically assessed.
• Surface science: Technologies for understanding the metal surface with the ability to measure, interrogate, visualise and modify it.

Challenges to overcome:

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

Biofilm Engineering

Unmet needs:

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

Challenges to overcome:

• The development and standardisation of experimental and monitoring methods including real-time, high throughput, large-scale and multi-variable.

Microbe - Metal Interactions

Unmet needs:

• Achieving improved risk assessment, prediction, and modelling (e.g. being able to predict and understand where, when, and why biofilms form in a particular system).
• The elucidation of coupled microbial metabolisms and potential novel bio-markers. Improved understanding of the interplay between microbes and the surface may lead to identifying key markers.
• Creating improved methods for detection of biofilms and monitoring of systems (e.g. deployable, accurate, sensitive biofilm/corrosion sensors).
• Identifying improved concepts to prevent biofilm formation (e.g. new materials/surfaces/coatings to disrupt biofilm life-cycle dynamics).

Next steps:

• A consortium with multiple industry and academic partners is needed to move ahead and impact on the challenges identified.
• Many of these are either training-based or exist in the precompetitive space and could be developed into a series of joint projects.

Microservices: Sensor technologies: Groups discussed the need for early detection and monitoring of biofilm formation and MIC occurrence. Sensors are a key tool to achieve this but have to be deployable, accurate and sensitive if they are to be of use to industry.

Materials/coatings: Approaches that enhance a surface’s ability to prevent biofilm formation are critical for addressing unmet needs. These could be improved surface designs, treatments and/or coatings.
Public Engagement and Outreach

Public Engagement (dialoguing with the public about our research) and Outreach (raising science 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 and Outreach Officer, and a Committee in place to support these activities.

We have conducted a wide range of activities across the UK (from biofilm dances to biofilms in a train station or IKEA), and we will keep doing this. We want to deliver our vision for Public Engagement and Outreach, laid out in our strategy developed this year. We want to reach the public with an active interest in biofilms related topics (home hygiene, healthcare, etc), inspire young people, and support everybody in NBIC with undertaking these activities.

We are continuously developing appropriate resources for wider use, and are leading and inspiring projects, for instance through our dedicated grant scheme, which offers up to £3000 for public engagement or outreach projects. Any NBIC affiliated individual/group can apply for this funding online, and they can also seek guidance and support directly from NBIC’s Public Engagement and Outreach Officer for their own projects.

Communications and Outreach

RAISING AWARENESS OF BIOFILMS IN THE UK AND BEYOND

Public Engagement and Outreach

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Communications

We recently launched our #BiofilmAware campaign. Through a blend of content, events and outreach activities #BiofilmAware works to raise awareness of NBIC and its research, and the societal and economic impact of biofilms. A highlight of the campaign will be the introduction of the UK’s first #BiofilmWeek, to be held in July 2021 to coincide with an NBIC event.

If you are interested in supporting the campaign, a range of digital resources are available on the NBIC website via the Campaign Hub.

Visit www.biofilms.ac.uk/biofilmaware to download and start sharing.

Since January 2020 our Twitter following has increased by 65%, and our LinkedIn following by 265% - with our overall social media engagement increasing by over 400%. As part of our #BiofilmAware campaign, we have launched NBIC Facebook and Instagram pages.

We have been looking at ways to improve the user experience, and traffic to the NBIC website. This has included the introduction of a blog page, with some fantastic contributions from NBIC team members and partners, the page currently ranks in the top 5 most visited pages on our site. Please get in touch with us if you would like to contribute.

Eurobiofilms 2019

NBIC HIGHLIGHTS

In September 2019 the NBIC team attended the Eurobiofilms conference in Glasgow. This was the first meeting we’d attended as a full NBIC team. It was a fantastic opportunity for us to meet our current partners and make new contacts.

We also had the honour to present at the final session on Friday 6 September 2019 and it was wonderful to see so many people in the auditorium nationally and internationally wanting to hear about what we do, how we do it and importantly why we do it! We are very proud that the UK is leading the way with a community like NBIC thanks to the support of our funders and that of the UK science and industry network. A number of other representatives from other countries approached us to discuss doing something similar.

Like the other sponsors and exhibitors, we engaged fully with the meeting and were made to feel very at home and welcomed by everyone.

Gordon Ramage and the Glasgow team had put on a great meeting in terms of the programme, location and events. The weather they couldn’t fix!

The poster sessions were lively, the innovative elevator pitch session fun, and we learned a lot and met so many new connections. We added over 50 new contacts and gained more than 60 new Twitter followers due to the event. Thank you to everyone who came and engaged with us – we loved meeting you all.

Images courtesy of Goode Photography

National Biofilms Innovation Centre

# BIOFILMAWARE

400%. As part of our #BiofilmAware campaign, we have launched NBIC Facebook and Instagram pages.

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In March 2020 our CEO, Mark Richardson visited the Global Challenge Research Fund (GCRF) Affordable Healthcare Workshop in Pakistan. He was joined by our university partners from Lancaster, Sheffield and Leeds to share our expertise in harnessing biofilms with healthcare professionals in the emerging nation and attendees even had an unexpected brush with the President of Pakistan, Arif Alvi, following a dinner invitation to the President’s house.

The GCRF is a £1.5 billion fund launched by UK Research and Innovation (UKRI) in late 2015 to support cutting-edge research that addresses the challenges faced by developing countries. These challenges result in funding calls and ahead of an anticipated call involving UK and Pakistan, a three-day workshop was funded in Islamabad.

Mark Richardson said, “I met scientists from Pakistan, Sri Lanka, Iraq and those thinking about science, technology, patient involvement, policy direction and health economics – the energy and engagement was amazing.”

The workshop brought together researchers, industry partners and decision makers to create a joint UK-Pakistan programme of expertise to support the translation of clinical, bio materials and biological science to low-cost healthcare products and innovative technologies that could be used locally in Pakistan.

This would be particularly by clinics to treat disorders of both soft and hard tissues. Existing products are currently unaffordable imports to most of the population, resulting in avoidable suffering and poor clinical outcomes such as amputations or death.

Mark Richardson continued, “Detecting and managing biofilms and infection is a key unmet need - before joining NBIC I worked for 25 years in industry in the wound healing field, so I appreciate how complex and costly current approaches are to solving this problem.”

As a country of over 200m people, Pakistan has a 12% incidence of type 2 diabetes and around 7% of these will have a foot ulcer at risk of infection and possible amputation each year. Our NBIC network has an invaluable knowledge of the relationship between biofilms and diabetic foot ulcers and during the visit we were able to share this at the workshop to support the research into the prevention of these problems in Pakistan.

Both the UK and Pakistan’s Governments shared vision is to create affordable high-quality healthcare products in Pakistan via indigenous sustainable resources with direct outcomes on patient healthcare. A common theme is the design, research and development of low-cost healthcare technologies that are clinically directed and for local need, based on simple cost-effective approaches for improving healthcare and the wellbeing of patients.

The workshop was a unique opportunity to work in diverse teams, generate new ideas and share best practice, which resulted in some exciting outline projects and as a result of this we’ve now created a virtual working group with connections made during the visit to develop a proposal and we hope to apply for a GCRF funding call soon.

**NBIC INTERNATIONAL STRATEGY**

The overall goals and strategic intent of NBIC international collaboration is to leverage our current position within the global scientific biofilm community and prioritise outreach to key developed and emerging regions. NBIC’s first governing principle is to promote excellence in science.

Therefore, our international strategy strives for a balance of:

- Working with biofilm academic centres that are prominent and striving to advance the field.
- Acquiring new contacts in other regions supported by international grants for the developing world.

Therefore, whilst we will actively explore new opportunities for biofilm research in India, Pakistan and China, we also continue to build on our existing relationships with SCELSE/SNBC in Singapore, CBE in the USA, the Costerton Biofilm Centre in Denmark and Stellenbosch University in South Africa to explore academic, industrial and regulatory synergies.

We also aim to establish international industrial contacts where these can stimulate the growth of the UK science and industrial base in translational biofilm research. This will further expand the reach of our collective scientific expertise and the relevance we can offer to our internationally operating industrial partners through demonstrating our global awareness.

Our aim, as a consortium of 52 UK Universities is to become a strong partner to a larger, powerful and influential international network of industry and academic partners.
In February 2020, NBIC along with the US Center for Biofilm Engineering, the Singapore Centre for Environmental Life Sciences Engineering (SCELSE), and an EU Cooperation in Science and Technology (COST) action group formed a task group to drive the international development and acceptance of standardised biofilm test methods in health care, the built environment, and industrial systems. Our goal is to enable informed and consistent decision making on the international regulation of anti-biofilm products. Our collective aim will be to:

- Communicate to regulatory decision makers the importance of using biofilm methods for biofilm specific label claims.
- Promote to public officials the need to set global biofilm standards through a consortium of established and recognised regional expert organisations.
- Standardise and validate biofilm test methods that are referenced in regulatory guidance documents.
- Promote the use of statistically validated biofilm methods when regulating products with a “kills” or “prevents” biofilm label claim.
- Leverage the global nature of the consortium to adapt testing methods across geographies.
- Engage industry, research institutions and academic stakeholders in the method development process.
- Champion biofilm methods in country and industry specific standard setting committees.
- Promote international consensus in the biofilm methods recognised in regulatory guidance documents.

Supporting researchers in gaining industrial experience

Dr Chris Winnard joined Next Generation Sequencing (NGS) company YouSeq, on an NBIC funded internship in the summer of 2019, where he was tasked with taking a new prototype for a next generation sequencing (NGS) kit, for identifying bacteria in a mixed population, through to commercial product launch.

The kit is based on a method known as 16S sequencing, which reads a region of the bacterial genome known as the 16 rRNA and then identifies which bacteria are present based on genomic information. 16S sequencing already exists, however the workflows are cumbersome and require long, highly skilled hours on the benchside. YouSeq’s new prototype transforms that complex workflow into a very simple closed-tube system that any technician can perform with ease.

Performing detailed studies on sensitivity and specificity, Dr Winnard identified final issues and implemented improvements to make the new kit robust for commercial use and produced good quality data to satisfy the company’s quality standards, resulting in a successful product launch. He was also involved in the beta version of launch, with trials of the kit occurring in the USA, South Africa, Portugal and the UK, where he took part in commercial and technical discussions with the company’s first significant customer. During the product launch Dr Winnard also supported the marketing function, which included developing a website, the instructions-for-use and creatively contributed to printed content.

Dr Chris Winnard

Dr Chris Winnard has a PhD in Clinical and Environmental Microbiology and a MBioSci (1st Class Honours) in Biomedical Sciences. His research interests revolve around DNA sequencing with a particular focus on the interplay between the microbiome and human health and disease. He is currently working as a Molecular Biology Scientist for a multinational sequencing service company specialising in RNA sequencing and library preparation.
Helping industry find academic partners to solve unmet needs

Central Venous Catheters (CVCs) are used in hospitals to deliver fluids, including medication, blood products, and nutrients into the veins of patients for extended periods of time. However, bacterial adhesion to the surface of catheters can lead to the growth of attached bacterial communities, known as biofilms.

Biofilm growth on catheters poses a serious infection risk for patients. In the UK alone, central venous catheter-related bloodstream infections account for 10-20% of hospital-acquired infections, increasing mortality, treatment costs and lengthy hospital stays.

Kimal PLC are a leading manufacturer and supplier of CVCs and dialysis catheters, providing disposable medical devices to hospitals around the world. At their innovation centre in Bromsgrove, their dedicated research and development team work on new products to improve patient outcomes.

Bacterial biofilm formation is complex and despite the severe infection problem that biofilms pose, there is little insight into how they form in venous catheters.

Through a Proof of Concept award from NBIC, researchers at the University of Edinburgh, Dr Susana Direito and Professor Rosalind Allen, worked with Kimal PLC to explore how three aspects of catheter design impact biofilm formation, using fluorescence microscopy, Scanning Electron Microscopy (SEM) and X-ray computed tomography; with a long-term goal of optimising their catheter products to reduce catheter associated infections.

The catheter design elements investigated were the shape of the lumen (interior tube), the size and shape of the skives (holes through which fluids exit the lumen) and the catheter surface coating.

The project was highly successful, and it identified immediate manufacturing steps that could be taken to improve catheter design and reduce biofilm formation.

To support future work with Kimal PLC, a PhD studentship was established through the Engineering and Physical Sciences Research Council (EPSRC) Soft Matter and Functional Interfaces (SOFI) CDT programme which works to provide industrially integrated post-graduate training in research, enterprise and innovation for future industry leaders.

Further funding applications are also in the pipeline.

The efficacy of Fourth State’s innovative plasma (ionised gas) technology for biofilm prevention and management on food and hard surfaces.

Fourth State is a micro-SME with ambitions of becoming a leading global provider of atmospheric pressure plasma solutions in healthcare and other adjacent markets. Plasma is the ‘fourth state of matter’ and consists of ionised gas. Examples in nature include lightning strikes, the aurora and the sun, while historical technological applications include etching of silicon chips for smartphones, advanced space propulsion systems and controlled nuclear fusion reactors. The company founders, Dr Thomas Frame and Dr Thomas Harle, saw an opportunity to use their technological expertise in spacecraft systems engineering and applied plasma physics to address urgent terrestrial needs, such as antimicrobial resistance. The team has since developed and patented an innovative platform plasma technology, and developed the company’s first product, Nebulaskin®, for non-surgical cosmetic procedures with a number of leading Harley Street clinics. A disruptive wound care product is currently in development.

Dr Harle said, “Fourth State sees biofilm management and prevention as a future ‘killer app’ for plasma technology across a wide range of sectors, so it’s fantastic to be working with NBIC to accelerate development and market access for the technology. Access to NBIC Proof of Concept funding has allowed us to build out our network, explore the expansion of our technology into further sectors and provide us with a deeper understanding of the science behind the interaction of plasma and biofilm”.

Dr Eirini Velliou, University of Surrey said, “I find the breadth of the NBIC network and remit fascinating. It allows the conduction of so many different types of research on biofilms and enables academics to network with other relevant groups at both a national and international level and encourages academics to work directly with industry to drive solutions to practical problems through fundamental research. This interaction is very valuable as we really see our research output accelerated from bench to every-day practice in industry”.

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Professor Rosalind Allen is a Professor of Biological Physics at the University of Edinburgh. Her research interest is focused on how nutrient cycling microbial ecosystems establish themselves and maintain their function.

Dr Susana Direito is a part of the Edinburgh Complex Fluids Partnership team within the University of Edinburgh and is also an NBIC Interdisciplinary Research Fellow. Her research interests include biofilm formation and advancing antimicrobial technologies.

Dr Eirini Velliou is Senior Lecturer (Associate Professor) of Bioprocess & Tissue Engineering, Principal Investigator and Founder of the Bioprocess and Biochemical Engineering group (BioProChem) in the Department of Chemical and Process Engineering at the University of Surrey. Her research focus falls within the engineering and validation of novel biomaterial based in vitro platforms for studying various biological systems and diseases, i.e. cancer, stem cells expansion and differentiation, formulation and communication of bacterial communities and bacterial-host interactions.

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Dr Eirini Velliou, Principal Investigator
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Two major clinical challenges in the treatment of chronic wounds are the management of wound exudate and the effective treatment of biofilm-related infections. Wound dressings are available to absorb exudate from highly exuding wounds and to treat wound biofilm infections; however, there is no commercially available single product, which collectively addresses both issues. To treat infected wounds with high levels of exudate a clinician currently uses two dressings; an anti-microbial dressing and a dressing to manage high exudate levels.

A Proof of Concept (POC) award from NBIC enabled researchers at the University of Manchester, Dr Gurdeep Singh and Professor Andrew McBain to work with Dr Helen Thomason, then Head of Scientific Research for Crawford Healthcare. Crawford Healthcare is a rapidly growing leader in developing innovative wound care and dermatological treatments and was acquired in 2018 by the world’s largest wound care company, Acelity L.P. Inc.

The main aim of the project was to assess the anti-biofilm efficacy of combining an antimicrobial dressing with a wound dressing, capable of absorbing high levels of exudate, to facilitate the treatment of wound infection and to manage exudate with a single treatment. The project was highly successful, meeting all major aims, and a manuscript is currently in preparation.

Science-based technology company 3M completed the acquisition of Acelity L.P. Inc. and its KCI subsidiaries in 2019. NBIC has recently supported the Dr Gurdeep Singh, Professor Andrew McBain and Dr Helen Thomason team to conduct further work on innovative wound care approaches, this time with 3M as the industrial partner.

The main aim of the research is to develop an in vivo wound model to assess the effects of biofilm formation and anti-biofilm dressings on single-cell spray-on skin therapy to promote healing. Spray-on skin therapy is a novel and effective way to promote healing of wounds such as burns and venous and diabetic foot ulcers.

The innovative approach of the project was the development of a synergistic combination of both antimicrobials in combination with 5D’s patent protected antibiofilm agents into one formulation, and its incorporation into modern hydrogel-based low adherent fibrous wound dressing. Two synergistic compositions, including metalised chelating agents applied to both carboxymethylcellulose and alginate substrates exhibited outstanding antibiofilm performance. With further development work, these technologies could be readily commercialised by companies operating in the advanced wound care space.

INNOVATIVE WOUND CARE

Helping industry find academic partners to explore new applications for a known technology

Two major clinical challenges in the treatment of chronic wounds are the management of wound exudate and the effective treatment of biofilm-related infections. Wound dressings are available to absorb exudate from highly exuding wounds and to treat wound biofilm infections; however, there is no commercially available single product, which collectively addresses both issues. To treat infected wounds with high levels of exudate a clinician currently uses two dressings; an anti-microbial dressing and a dressing to manage high exudate levels.

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NEXT GENERATION WOUND TREATMENT

Helping industry find academic partners to explore new applications for a known technology

Annually over 18 million patients globally suffer from chronic wounds, of which over 50% will develop a localised infection due to biofilms, a major impediment to wound healing, and long-term health. This can lead to increased health service costs, morbidity and further complications for the patient, which ultimately includes amputation. The indicative annual cost for wound management in Europe accounts for 2–4% of healthcare budgets and has been estimated to be as high as €10 billion.

Current antimicrobials in wound care have limited effectiveness against biofilms. The project, ‘Development of Next Generation synergistic antibiofilm treatments for wounds’ was awarded an NBIC Proof of Concept (POC) award and in-kind contributions from 5D Health Protection Group Ltd, enabling process development work and prototype production to be carried out at the University of Leeds, whilst 5D Health Protection Group Ltd supplied raw materials and carried out antimicrobial and antibiofilm testing.

The innovative approach of the project was the development of a synergistic combination of both antimicrobials in combination with 5D’s patent protected antibiofilm agents into one formulation, and its incorporation into modern hydrogel-based low adherent fibrous wound dressing. Two synergistic compositions, including metalised chelating agents applied to both carboxymethylcellulose and alginate substrates exhibited outstanding antibiofilm performance. With further development work, these technologies could be readily commercialised by companies operating in the advanced wound care space.

The model is used to reproduce biofilms on glass coupons under defined conditions suitable for testing the efficacy of antimicrobials and materials impregnated with antimicrobials. The model can be adapted to allow for the growth of biofilm on skin and wound dressings.

Dr Steve Law, Research and Innovation Manager, 5D Health Protection Group Ltd said, “The novel antibiofilm technologies had been developed to laboratory scale by 5D, but the NBIC award allowed the exploration of how the technologies could be applied on modern wound care substrates and also enabled evaluation of wound dressing prototypes in robust antibiofilm models”.

The project has been successfully completed, with all outcomes achieved. Two routes for advancement of the project are being pursued: sharing of the results with targeted industry partner(s) with a view to generate collaboration and co-development projects, and to seek further funding based on further development of synergistic antibiofilm compositions and further development of deployment techniques.

Professor Andrew McBain, Principal Investigator
Professor Andrew McBain studied for his PhD in Medical Microbiology at the University of Cambridge with the Medical Research Council. Since 1999, his research at Manchester has focused on the responses of biofilms to antimicrobial treatments and the interaction of microorganisms colonising the skin, nasopharynx, oral cavity and intestine with the human host in health and disease.

Professor Stephen Russell
Professor of Textile Materials and Technology, and Director of the Clothworker’s Centre for Textile Materials Innovation for Healthcare, at the University of Leeds.

Dr Steve Law
Industry Collaborator
Research and Innovation Manager at 5D Health Protection Group Ltd. Dr Law has over 25 years’ experience in the innovation and development of polymeric materials.
Helping to support biofilm models to assess novel interventions

Indwelling urinary tract catheters are the most commonly employed implanted medical devices. However, indwelling catheters promote catheter-associated urinary tract infections (CAUTIs) that, if left untreated, may lead to acute pyelonephritis, urosepsis and death. Treatment for CAUTIs usually depends on catheter removal and antibiotic therapy. Worldwide, 70-80% of the 150 million urinary tract infections reported annually are CAUTIs which impose both serious health problems and a significant economic burden.

Attempts to reduce the likelihood of CAUTIs have focused on improved hygiene, intermittent catheterisation and the development of novel catheter materials. Efforts to develop biocompatible catheter materials that resist biofilm formation have focused on the incorporation of antimicrobial agents by impregnation into, or surface conjugation onto, the biomaterial. However, silver-coated catheters have been disappointing in clinical use while impregnation with antimicrobials suffer with loss of efficacy as the active agents leach away. They also increase the challenges associated with the emergence of multi-antibiotic resistant pathogens. Consequently, the ideal urinary catheter biomaterial should prevent biofilm formation in the first place.

Professors Morgan Alexander and Paul Williams are NBIC Co Investigators from the University of Nottingham. With support from the Wellcome Trust he is a Wellcome Trust Senior Investigator and Director of a EPSRC Programme Grant in Next Generation Biomaterials Discovery at the 3D OrbSIMS facility and a Wellcome Trust Senior Investigator.

The Nottingham NBIC Innovation Research Fellows and the EPSRC-funded ‘Next Generation Biomaterials’ team in July 2019 at the Royal Society Summer Science Exhibition in London.

In collaboration with Professor Derek Irvine from the University of Nottingham, and NBIC partner Camstent Ltd, a polyurethane-coated urinary tract Foley catheter has subsequently been developed and manufactured, receiving CE mark approval in 2017 for clinical use in hospitals in the UK and Europe.

In collaboration with the Nottingham NBIC Innovation Research Fellows and the EPSRC-funded ‘Next Generation Biomaterials’ team, this topic was presented at the Royal Society Summer Science Exhibition in July 2019. The Great Greeting Experiment, a live research project developed by NBIC Co Investigator Dr Kim Hardie from the University of Nottingham, used UV iridescent powder and a UV light box to allow volunteers to observe transference and the effectiveness of hand washing. ‘Stick or Slide’ and ‘Stop the Superbugs’ exhibits illustrated how difficult it is to remove a biofilm and how our novel catheter biomaterials work to prevent infection.

Professor Paul Williams
Paul Williams is Professor of Molecular Microbiology at the University of Nottingham. He is a Welcome Trust Senior Investigator and Director of a Welcome Trust PhD Training Programme in Antimicrobials and Antimicrobial Resistance.

Professor Morgan Alexander
Morgan Alexander is Professor of Biomedical Surfaces at the University of Nottingham, Director of the EPSRC Programme Grant in Next Generation Biomaterials Discovery at the 3D OrbSIMS facility and a Wellcome Trust Senior Investigator.

Proof of Concept Projects
SUPPORTING TRANSLATIONAL ACTIVITY

Our investment in biofilm innovation

To date, we have run three POC calls attracting 144 applications from which we awarded funding to 65 projects. This represents an investment of £3.6m from NBIC and £5.4m total value when we also consider funds from companies either in cash or in-kind. These awarded projects have involved 28 research institutions, 52 companies and of these companies, 33 are SMEs. These applications have shown a spread across our four key interventional themes with each successive call showing a more even balance as our outreach takes effect. In addition, they have seen engagement from a diverse set of industrial sectors demonstrating the broad impact of biofilms. A full list of projects are provided in this annual report from page 34.

Proportion of applications to NBIC POC calls to date shown by industrial sector

The projects establish the feasibility of a concept, idea or technology from any application sector which is aimed at preventing, detecting, managing or engineering biofilms. The scope was for projects at Transfer Readiness Level 2-4 which were a collaboration between a member UKRI 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 POC1 for example we had 15 RI and 30 companies who jointly applied, and in POC2 there were 29 RIs and 31 companies (25 of which had not applied in POC1). There was also wider sectorial spread and an improved balance of interventional themes (Prevent, Detect, Manage and Engineer) from POC1 to POC2.

Proportion of applications to NBIC POC calls to date shown by Interventional theme
In POC3 we received 45 applications from 24 different research institutions involving 46 companies. This third group of projects continues to address a wide range of sectors and challenges across health, hygiene, industrial processing, food, water, oral care, personal care, anaerobic digestion, waste and wastewater and biotechnology. We had reserved 30% of funding for projects with an Engineering theme to build on our Biofilm Engineering workshop, which took place in Edinburgh in April 2019. In fact, we are delighted that over 40% of funding was awarded to projects with a clear Engineering theme (this definition for each project was checked by project reviewers). This demonstrates the impact our networking and workshops had on stimulating these applications.

This third set of awarded projects brings our total portfolio of funded projects to 65 across diverse companies, sectors and research institutions. As the first of our portfolio of projects come to completion and mature, we are now looking to see their further progress and how NBIC can help. In the current Covid-19 affected science landscape we are working with holders of active projects to understand how NBIC can be flexible and help them ensure their projects successfully complete.

**POC3 APPLICATIONS**

**POC3 Applications**

<table>
<thead>
<tr>
<th>Interventional Theme</th>
<th>% of Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health</td>
<td>37%</td>
</tr>
<tr>
<td>Waste &amp; water</td>
<td>12%</td>
</tr>
<tr>
<td>Personal care</td>
<td>11%</td>
</tr>
<tr>
<td>Food &amp; agriculture</td>
<td>11%</td>
</tr>
<tr>
<td>Energy-Anerobic Digestion</td>
<td>1%</td>
</tr>
<tr>
<td>Biotechnology</td>
<td>4%</td>
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<tr>
<td>Marine</td>
<td>8%</td>
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<tr>
<td>Industrial processing</td>
<td>15%</td>
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<tr>
<td>Oral</td>
<td>7%</td>
</tr>
<tr>
<td>Biotechnology</td>
<td>4%</td>
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<tr>
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<td>11%</td>
</tr>
<tr>
<td>Energy-Anerobic Digestion</td>
<td>1%</td>
</tr>
<tr>
<td>Health</td>
<td>33%</td>
</tr>
<tr>
<td>Waste &amp; water</td>
<td>7%</td>
</tr>
<tr>
<td>Personal care</td>
<td>4%</td>
</tr>
</tbody>
</table>

**POC3 Awarded**

<table>
<thead>
<tr>
<th>Interventional Theme</th>
<th>% of Projects Approved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health</td>
<td>38%</td>
</tr>
<tr>
<td>Waste &amp; water</td>
<td>12%</td>
</tr>
<tr>
<td>Personal care</td>
<td>11%</td>
</tr>
<tr>
<td>Food &amp; agriculture</td>
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<td>Energy-Anerobic Digestion</td>
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<td>Energy-Anerobic Digestion</td>
<td>1%</td>
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<td>Health</td>
<td>33%</td>
</tr>
<tr>
<td>Waste &amp; water</td>
<td>7%</td>
</tr>
<tr>
<td>Personal care</td>
<td>4%</td>
</tr>
</tbody>
</table>

We will run our fourth Proof of Concept project call at the end of 2020 and will consider later TRL levels as our portfolio and the needs of the community mature. In addition, with the £1m in-kind investment from the Science and Technology Facilities Council (Hartree) we will run a funding call for collaborative projects requiring data analysis and High-Performance Computing (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.

**Building a shared language for dialogue.**

We have spent time across our industry/academic community understanding the language and terminology of biofilms and this has been captured as an ontology in Mindmap form on our website. This was developed in conjunction with 80 UK researchers (in industry and research institutions) to capture how they talk about and describe biofilm research, problems and opportunities.
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/fight and manage biofilms by comparing biofilm behaviour using innovative analytical techniques.

University of Sheffield
International Paint Ltd (IP), Mooredown and Dérik Gymsu Welsh Water (DGWW)

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
SD Health Protection Group Ltd

BIORLMer: 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 Mxing 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 consortium 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

Proof of Concept 1

AWARDED OCTOBER 2018

PROJECT TITLE | PROJECT SUMMARY | UNIVERSITY/RESEARCH INSTITUTION | INDUSTRY COLLABORATOR/S
---|---|---|---
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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-use compliance within surgical theatres. Detailed surface chemistry and biological testing will accelerate commercialisation of existing IP. | University of Liverpool | Gencoa Ltd |
Measuring biofilm formation in venous catheters | The placement of catheters into a patient’s veins is widespread in hospitals, but poses a serious infection risk due to biofilm formation. We will measure biofilm formation on a range of catheters provided by Kimal Plc, to determine how catheter design can be improved to reduce the risk of biofilm formation. | University of Edinburgh | Kimal Plc |
Corneal biofilm models and anti-biofilm nanoparticles | Bacterial and fungal keratitis is a major problem in many low/middle-income countries (LMIC). There is a need for stable and affordable treatments that can control diverse eye infections. Antimicrobial and physical properties needed to destroy biofilm structures without damage to sensitive eye tissue. | Sheffield University | Tecrea Ltd and Blueberry Therapeutics |
Low dose nitric oxide for the effective treatment of chronic wounds | Wounds that don’t heal are associated with bacteria in communities known as biofilms which are resistant to antibiotics. We have shown that low dose nitric oxide can help disperse lung biofilms win patients with cystic fibrosis. This project will test whether nitric oxide can also disperse biofilms from infected wounds. | University of Southampton | Smith & Nephew Ltd |
Blue light treatment of Listeria under environmental conditions | Listeria monocytogenes is an important foodborne pathogen, causing recent fatal outbreaks across Europe and South Africa. Listeria is found 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 |
PLAUSIBLE PROJECTS | | | |
Development and evaluation of a dual function dressing to combat biofilm infection and exudate in chronic wounds | Dressings have been designed to separately address problems associated with chronic wounds including exudate (wound fluid) and biofilms (microorganisms growing on surfaces that are highly tolerant to antimicrobials). This project will assess the anti-biofilm efficacy of a newly developed wound dressing capable of absorbing high levels of exudate. | University of Manchester | Crawford Healthcare |
The effect of low frequency ultrasound on urinary catheter biofilms: a crossover study | Finding ways to reduce infections caused by catheters (tubes) in the bladder is a top priority in the NHS. We have evidence that an ultrasound device (Uroshield) that clips onto catheters could prevent infections. In this study we will use proven methods to find out if it really works. | University of Southampton | Nanovibronix Inc (Ideal Medical Solutions UK) |
Development of crystalline platform for the analysis of biofilms | Using innovative analytical techniques. | | |
Development of a novel high value strains. | | | |
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Development of a novel high value strains. | | | |
In the food industry, increased resistance of biofilm-forming bacteria such as *Listeria* has led to a need for new approaches for decontamination of food and food processing surfaces. This project will evaluate an innovative plasma decontamination platform to address key performance variables for antimicrobial products on domestic surfaces.

**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.

**Facile fabrication of a disruptive titanium dental implant 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.

**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.

**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.

**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.

**Evaluating an innovative plasma (fourth state of matter) technology for prevention and management of biofilms in the food industry**

In food industry, increased resistance of biofilm-forming bacteria such as *Listeria* has led to a need for new approaches for decontamination of food and food processing surfaces. This project will evaluate an innovative plasma (fourth state of matter) technology for biofilm prevention and management on food and hard surfaces.

**Treatment of zinc-contaminated dairy in steel production by Biocatalytic Systems**

In steel industry, Basic Oxygen Steelmaking (BOS) generates significant amount of dust with high Fe content. 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 Biocatalytic System (BES) to tackle this challenge.

**Novel pharmaceutical agents (XF-drugs) to prevent and proactively manage bacterial biofilms 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 (DFUs). The purpose of this PhD study is to examine the effectiveness of a novel antimicrobial-drug series in two mechanistically-distinct and clinically-relevant model systems.

**Development of next generation synergistic antimicrobial 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.

**Influence of phosphate dosing to prevent plumbosolvency on biofilm formation in drinking water distribution systems**

Phosphate is added to drinking water to minimise lead leaching from household pipes. However, phosphate, can favour microbial biofilm formation in drinking water systems. To optimise the use of this chemical that is used by water utilities, we need to understand its impact on biofilm formation and on water quality and safety.

**Biofilm evolution in microbial fuel cells fed Yeo Valley wastewater**

Yoghurt production generates wastewater that requires considerable energy to treat. 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.
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 in situ underwater optical sensors

There is a growing market in the Marine and Freshwater sector for in situ sensors to monitor water environments. A significant bottleneck is rapid instrument failure due to biofouling of sensor windows. This project will: (i) create smart antiBiofouling windows; (ii) modify and upgrade current sensors for underwater biofilms identification.

University of Liverpool  Chelsea Technologies Group Ltd

Enhanced biofilm detection methods using 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 UVC as a cost-effective, reliable and non-destructive remediation tool for many endangered historic buildings.

University of Portsmouth  Historic England & Isle of Wight Heritage Service, Isle of Wight

Branched functional polymers for disrupting bacterial biofilms

Biofilms in wounds and on medical devices are a major problem that prevents 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  SD Health Protection Group Ltd

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University of Portsmouth  Historic England & Isle of Wight Heritage Service, Isle of Wight

The effect of electrosuprananofibre diameter and 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 nanofibres of different diameters changing their morphology (size / shape) improving antimicrobial properties and colonisation resistance of wound dressings.

Swansea University  Hybrisan

e-Biofuels from CO2 conversion using microbial electrosynthesis

e-Biofuels 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.

University of Portsmouth  Loughborough University  Shell Research Ltd

HullSense

We will design, build and test a working prototype biofilm sensor that will sense microfouling, in real-time on ship’s hulls. This direct measurement of biofilm will allow in-water hull-cleaning to be correctly scheduled to: extend longevity of coatings, reduce fuel consumption and reduce greenhouse gas emissions.

Plymouth Marine Laboratory  Valeport Ltd

Biostabilisation of biofilms on medical devices and forensic artefacts

We have recently demonstrated the potential to repurpose existing licensed drugs as antibiofilm agents, with an initial focus on catheter associated urinary tract infection.

University of Bath  Public Health England and King’s College London

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

Development of new antibiotic agents through repurposing of existing licensed drugs

We have recently demonstrated the potential to repurpose existing licensed drugs already used in human medicine as antibiotic agents. This project will provide a comprehensive screen of available drugs to identify the best candidates for repurposing as antibiotic agents, with an initial focus on catheter associated urinary tract infection.

University of the West of England (UWE), Bristol  University Hospitals Bristol NHS Foundation Trust and Altered Carbon

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
<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>PROJECT SUMMARY</th>
<th>UNIVERSITY/ RESEARCH INSTITUTION</th>
<th>INDUSTRY COLLABORATOR/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact of ozone applied in the food processing environment on Listeria monocytogenes biofilms</td>
<td>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 AnaCall’s high-dose ozone in factory-relevant conditions on drain covers.</td>
<td>James Hutton Institute</td>
<td>AnaCall Ltd</td>
</tr>
<tr>
<td>Bacterial networking: why it’s not always beneficial to build bridges and make connections</td>
<td>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.</td>
<td>University of Edinburgh</td>
<td>Vedia UK</td>
</tr>
<tr>
<td>Developing passive RFID technology to monitor Candida albicans biofilm growth on medical devices</td>
<td>Pathogenic yeasts can grow as biofilms on materials used to make medical implants, representing 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 help improve diagnosis and treatment.</td>
<td>University of Kent</td>
<td>Smiths Medical International Ltd</td>
</tr>
<tr>
<td>Label-free multimodal imaging platform for detection of biofilms</td>
<td>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, treatments avoiding microbial resistance and remove or promote biofilms in health and industrial applications.</td>
<td>University of Southampton</td>
<td>M Squared Life Ltd and University Hospital Southampton</td>
</tr>
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<td>Rapid screening platform for shortlisting coatings against infection</td>
<td>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.</td>
<td>University of Southampton</td>
<td>Public Health England and Center for Biofilm Engineering (CBE) Montana State University</td>
</tr>
<tr>
<td>Advanced biofilm removal mediated by targeted microbubbles generated by fluidic oscillation</td>
<td>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.</td>
<td>University of Sheffield</td>
<td>Perlemax Ltd</td>
</tr>
<tr>
<td>Automated in situ detection and monitoring of marine biofilm erosion and mechanical properties via custom optical coherence tomography (OCT)</td>
<td>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.</td>
<td>Newcastle University</td>
<td>International Paint Ltd (AkzoNobel) and University of Southampton</td>
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### Projects with Project Title: Development of a non-thermal plasma applicator system for the decontamination of medical endoscopes

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>PROJECT SUMMARY</th>
<th>UNIVERSITY/ RESEARCH INSTITUTION</th>
<th>INDUSTRY COLLABORATOR/S</th>
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</thead>
<tbody>
<tr>
<td>Validation of the Oxi-Cell Ozone System for the elimination of biofilms</td>
<td>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.</td>
<td>University of Southampton</td>
<td>Oxi-Tech Solutions</td>
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<td>Plasma for the prevention and management of chronic wound biofilms</td>
<td>Chronic wounds are costly to treat and significantly affect a patients’ quality of life. Bacterial biofilms (specific bacterial structures) play an important role in chronic wounds, and are responsible for many antibiotic treatment failures. This project will test an exciting new technology to remove wound biofilms and promote healing.</td>
<td>University of Hull</td>
<td>Fourth State Medicine</td>
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<td>Standardised complex wound biofilm models: a robust antimicrobial screening tool</td>
<td>Biofilms are rarely found comprised of one single type of microorganism, yet the development of new antibiotics tends to focus on testing one bacteria. This project aims to develop methods and testing platforms that will allow industry partners to develop an effective anti-biofilm compounds using a platform representative of wounds.</td>
<td>University of Glasgow</td>
<td>BluTest Laboratories</td>
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<td>Rapid early and accurate diagnosis of wounds</td>
<td>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.</td>
<td>Loughborough University</td>
<td>Smith &amp; Nephew Biomedical Ltd</td>
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<tr>
<td>Commercialisation of a burn wound biofilm model to provide a new tool to assess pre-clinical research and testing in academia and industry</td>
<td>Biofilm formation in burn wounds is associated with treatment failures, poor clinical outcomes, and development of chronic non-healing wounds. This project will develop a clinical burn wound biofilm model that can support both early-stage and commercial development of new products to control biofilm formation in wounds.</td>
<td>University of Bath</td>
<td>Perfectus Biomed Ltd</td>
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Develop a computational tool for marine biofilm management

Computational biofilm modelling has potential as a rapid, low cost route to accelerate ship fouling control coating research & development. This project aims to develop a unique computational tool to predict experimental data on marine biofilm erosion, deformation and drag at mesoscale flow cell as a Proof of Concept.

Biofilm production of Phaeodactylum tricornutum for fucoxanthin

A membrane-based bioreactor system utilising biofilm forming microalgae has been developed to solve the economic and logistical bottlenecks commonly associated with conventional microalgae production. This study will establish the economic viability of this novel process using the model marine diatom Phaeodactylum tricornutum for the production of the high-value pigment fucoxanthin.

Novel XF drugs in the topical management of Candida albicans biofilms

Oral fungal biofilms are common and responsible for a significant burden of infection in people. Successful treatment is hindered by biofilm resistance and limited numbers of effective antifungal drugs. This project will evaluate the novel XF drugs in combating Candida biofilms and reducing their infection risk using mucosal mouth models.

Development of molecular support to detect biofilm causing pathogens within chronic infections

The same species of microorganisms colonise skin and behave as pathogens. The biofilm phenotype has been proposed as a trigger for infection chronicity however organisms are not routinely screened for this. This project aims to identify genetic markers linked to biofilm that can be utilised by clinicians to detect biofilms.

Rotating spiral biofilm reactor for reliable engineering and control of bacterial communities and environments for use in industrial biotechnology

This project extends an existing technology based on rotating spiral channels to the challenge of harvesting microbial biofilms for sustainable production of valuable chemicals currently uneconomical to synthesise through alternative routes. The constructed prototype will act as an enabling technology and open up new markets for the industrial biotechnology sector.

Biofilm aggregates (diversity, function) influence nutrients bioavailability from complex food matrices. We will define how gut biofilm aggregates influence iodine bioavailability (nutrient of public health interest) from seaweed, an iodine rich food. Defining how to sustain engineer these biofilms will enable the industry partners to develop safe evidence-based products.

Manipulation of gut biofilms dynamics for enhanced iodine bioavailability

We aim to fight the bacteria that contribute to gum disease, by creating origami-like DNA nanostructures loaded with antibacterial enzymes or proteins. We will optimise the DNA origami to bind specifically to the target bacteria and to improve the penetration and disruption of the biofilms that they form.
Thank You

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For further information, please contact nbic@biofilms.ac.uk

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