CATAPULT
Medicines Discovery

Organ-On-A-Chip Technologies (OOAC):

Current status and translatability of data

Summaries and conclusions of a workshop debate in May 2018 between experts from industry, academia and the Medicines and Healthcare products Regulatory Agency (MHRA) on the subject of OOAC technologies.

Report produced in association with:

NC3Rs National Centre for the Replacement Refinement & Reduction of Animals in Research

MRC Centre for Drug Safety Science

This report provides a summary of an OOAC workshop and outlines the three key areas of focus for the UK to advance the technologies discussed. This is a joint report by Medicines Discovery Catapult, the Medical Research Council (MRC) Centre for Drug Safety Science (CDSS), based at the University of Liverpool, and the National Centre for the Replacement, Refinement & Reduction of Animals in Research (NC3Rs).

Contents

Executive summary

Organ-on-a-chip technologies (OOAC), or micro physiological systems (MPS), are new approaches to create miniaturised physiologically-relevant biological testing systems suitable for academic research and drug discovery. The aim is to create cell models, in an appropriate microenvironment with microfluidic flow, that mimic aspects of human organ level functionality. By interconnecting these models, meaningful and relevant biological interactions between organs can be achieved – delivering in vitro patient-relevant testing systems. These dynamic and responsive biological test platforms have the potential to revolutionise drug target identification and validation studies without the need for animal models. This will improve compound efficacy, safety and targeted drug delivery.

OOAC technology is rapidly developing. To better understand UK activities in this area, a workshop was co-sponsored by the CDSS at the University of Liverpool, the NC3Rs and Medicines Discovery Catapult. Invited representatives from across academia, small and medium business enterprises (SMEs), contract research organisations (CROs) and pharmaceutical companies met to take stock of the UK activities in this space. Attendees included OOAC technology vendors, users, cell model developers and representatives from UK grant funding bodies and the MHRA.

Themes discussed at the workshop included:

- The use and experiences of this technology in the pharmaceutical industry and CRO communities
- The development, qualification and translation of the microfluidic and biological systems
- An appreciation of the regulatory authority viewpoint
- A series of real world case studies describing their practical application

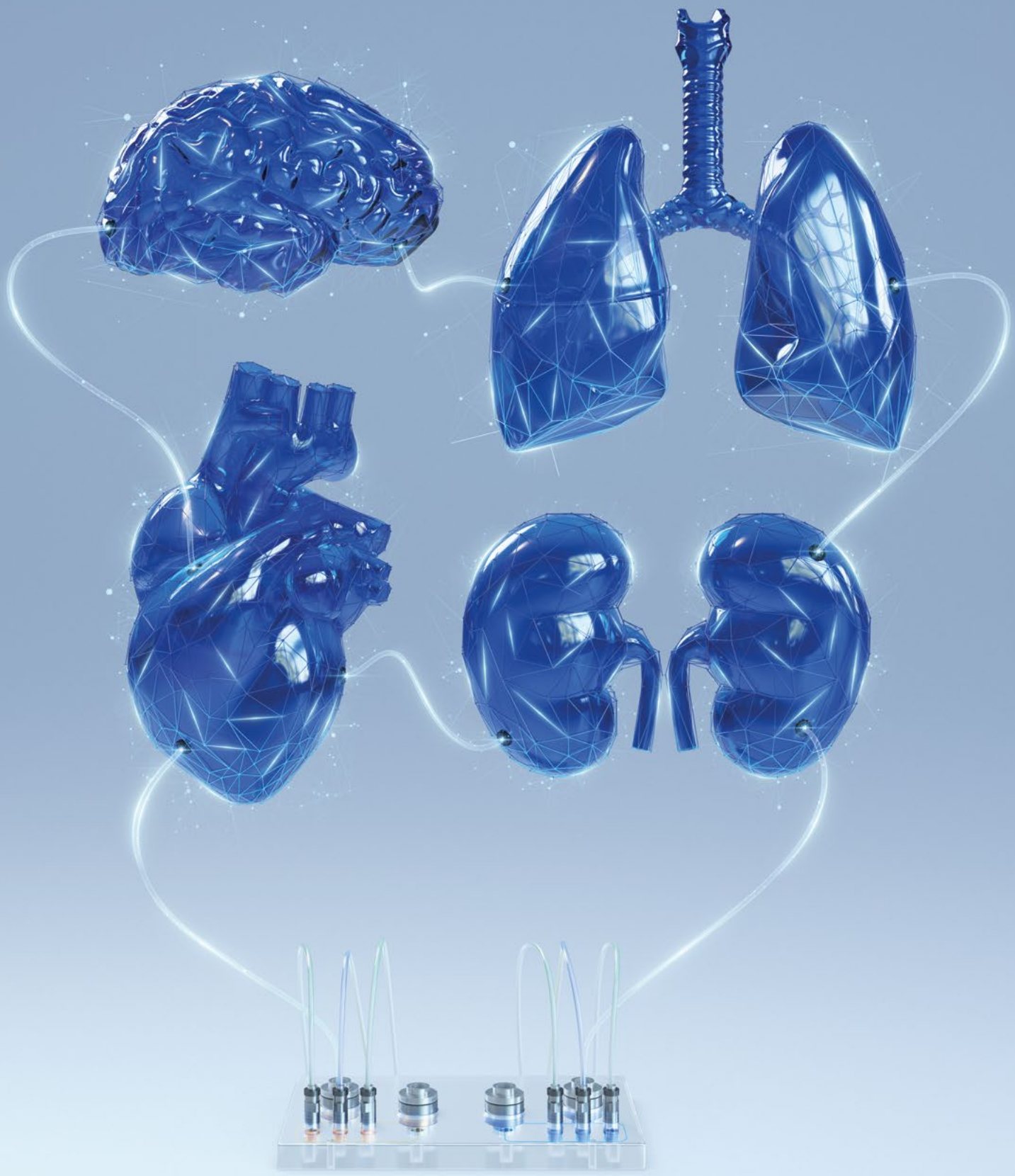
The presentations were followed by a discussion on challenges and opportunities of OOAC technology in the UK.

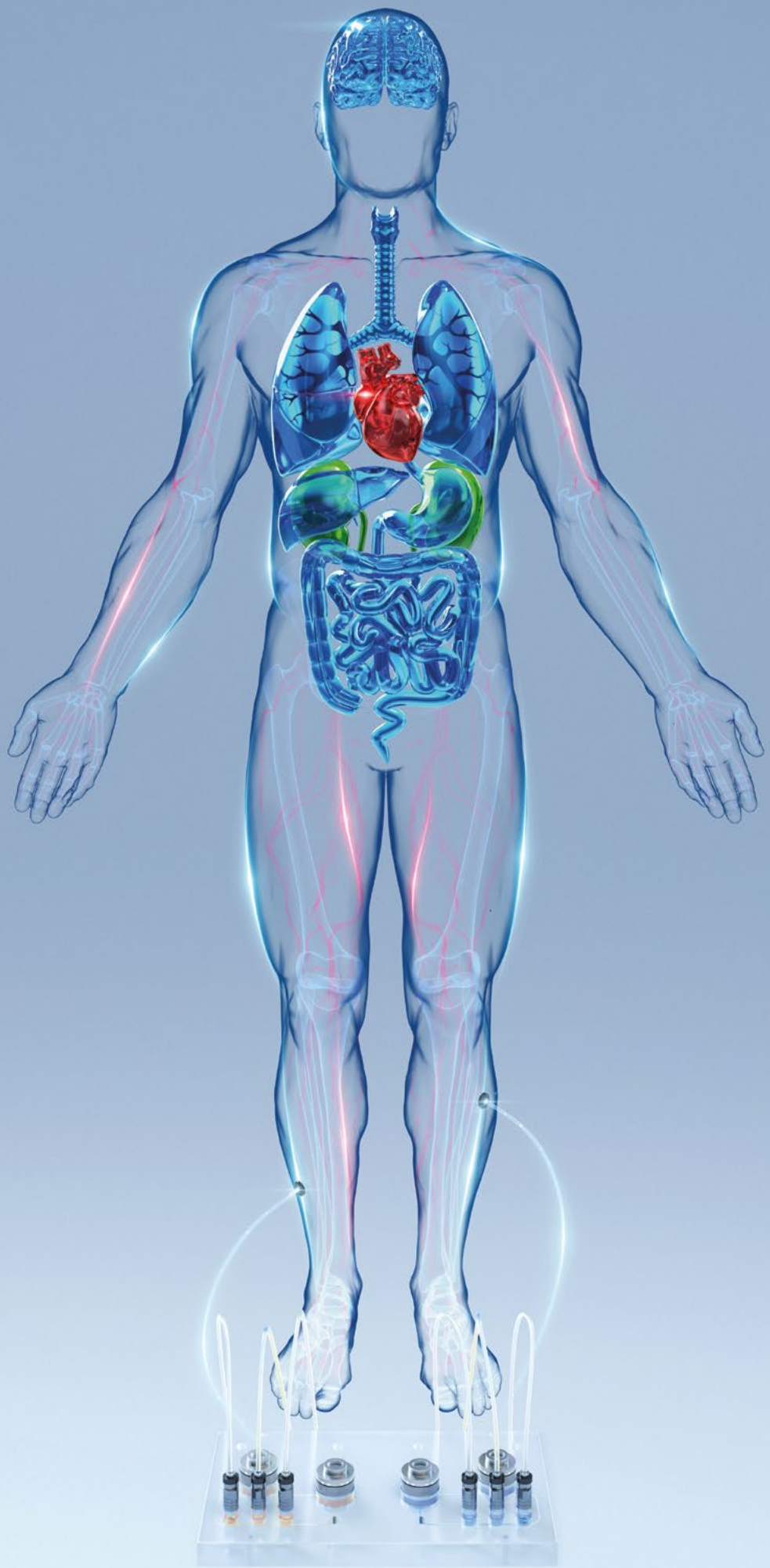
Discussions from the workshop were grouped into three areas:

- Development of a UK OOAC network
- Funding requirements
- Scientific and technical challenges and opportunities

Recommendations to progress OOAC technology within the UK, as a result of the workshop are:

- Establish a UK OOAC network community to bring together the current users and developers of on-chip technologies, along with relevant regulatory and funding stakeholders. The network should encourage technical and biological innovation by providing clear channels of communication to share experience. The network will aim to boost progress and return on investment (ROI) and avoid repetition of unproductive technical processes. It will also be a way of guiding the delivery of biological cell models from the UK science base towards technologies that adequately fulfil the required aspects of organotypic function.
- Engage with the regulatory authorities and UK funders to help progress this new and innovative technological approach. Reach out to other science communities to explore how the sectors that generate human-relevant data inform decision making (e.g. the cosmetics industry). Establish where the UK has limited coverage or a gap that could be eased by connecting with European or US groups.
- Focus on the development and achievement of validated, robust and reliable single and two to three organ models, addressing a specific need. Address translational considerations during their development.





Introduction to OOAC technology

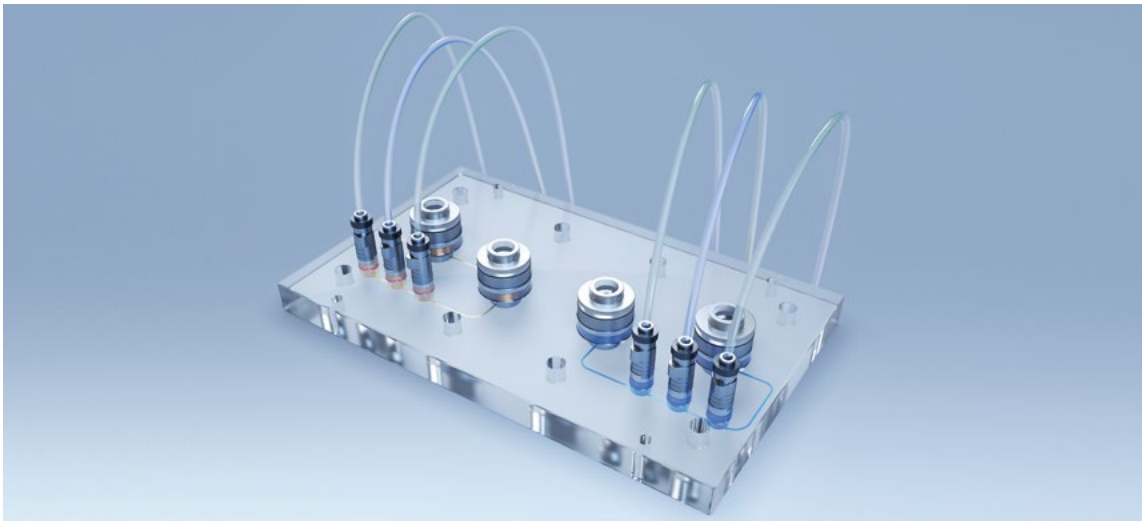
OOAC technologies or MPS, are new approaches to create miniaturised physiologically-relevant biological testing systems suitable for academic research and drug discovery. Innovations are required to improve the success rate of and ROI from existing drug discovery approaches. The development of improved cellular models, in isolation or connected by microfluidic flow, has the potential to improve target identification and validation, the detection of efficacious compound effects and unmask unexpected toxicological issues. Structural and environmental cues applied to relevant primary and stem cell models will help generate in vitro patient-relevant testing systems. These have the potential to revolutionise drug hunting activities. This will bring a new dimension to academic research around disease modelling and progression involving multiple connected relevant cellular models, whilst reducing our reliance on poorly predictive animal models.

To better understand activities, opportunities and challenges in the OOAC area in the UK, a workshop was co-sponsored by CDSS University of Liverpool, the NC3Rs and Medicines Discovery Catapult, hosted at the Sensor City in Liverpool.

Addressing utility of this technology, the technical and translational considerations alongside regulatory hurdles and funding opportunities were discussed with presentations and lively participant debate (Agenda, Appendix 1).

40 representatives across academia, SMEs, CROs and pharmaceutical companies were invited. Attendees included OOAC technology vendors, first-hand users, cell model developers, representatives from UK grant funding bodies and the MHRA (Attendees, Appendix 2).

A summary of the presentations, the discussion and output recommendations are presented in this report as a snapshot of the issues and opportunities in the UK around OOAC technology and cell model development.



Workshop presentation summaries

Overview of OOAC technology and its utility

Gianni Dal Negro, *GSK*

Striving for representative, validated and qualified 3D cell model systems is a challenge. However, it does offer the promise of a positive impact across the drug discovery pipeline from target identification and validation, through to efficacy and safety assessment. Understanding the relevance of a model to the specific biological question being studied is the key to successful development of these models. The limitations of such approaches must also be recognised. One model cannot answer all questions, and currently models typically lack integrated physiology and longitudinal measurement capacity.

While the incorporation of patient-derived material would be ideal, issues around robustness and reproducibility ultimately limit primary model utility across multiple applications. Also current organ-level cryopreservation methods are inadequate. Initial results from approaches involving induced pluripotent stem cells (iPSC) have been encouraging.

However, it seems likely that the inclusion of environmental signals, physical stimuli etc., will be necessary within iPSC differentiation protocols to generate cell types that better mimic adult tissue. For the promise of a human-on-a-chip to become a reality, many challenges remain to be overcome. These challenges include physically-relevant cell interactions, scaling ratios between organs, incorporation of immune or endocrine systems and the requirement for a common signal-carrying media flowed appropriately between the components. Progress in this area will require working across boundaries, to move from technology developers and users requiring qualification, to a standard attractive for industry adoption and prosecution.

OOAC translatability

Malcolm Haddrick, *Medicines Discovery Catapult*

OOAC presents an opportunity for translational models that better replicate the patient in healthy and diseased states, investigate patient-specific variations and assess systemic effects of drugs on the interconnected organs. This may help address the poor correlation between clinical and animal data, while implementing the 3Rs (replacement, reduction and refinement of animals in research). Most translational data comes from studies using single organ OOAC studies. These results have been encouraging when examining direct cellular effects (e.g. cardiomyocyte contractility in Barth Syndrome (Wang G, et al.) and some organotypic functions at the alveolar: capillary interface in a lung-on-a-chip model (Huh D, et al.)). Additional value may be generated from the understanding of multiple and more complex connected models. As the number of connected organs increases, technical, biological and translational complexity escalates such that a 'physiome' or 'human-on-a-chip' remains a distant achievable goal.

Technically, 4, 7 and 10 organ cultures have been connected in a microfluidic set-up, involving sub-circuits and tuneable flow rates, but so far only prolonged viability has been demonstrated for each organ component. For translatability, cell models need to be specialised, collectively-functioning populations of mixed cells capable of some functions of the organ they represent. Deficiencies here will accumulate as the number of connected systems grows, with the potential to reduce clinical relevance. While primary tissue is accessible, reproducibility and scalability are problematic. iPSC-derived cells often exhibit an immature phenotype, limiting their potential as an alternative to primary tissue and adding to the challenge of correlation with relevant clinical data. To monitor the health of the cell models and decipher their biological responses to target validation and compound evaluations, on-chip label-free, real-time, clinically-aligned biosensors will be required. This data-rich approach will be a considerable improvement on current limited mechanistic methods. The potential for high volume data generation needs to be matched with computational models to understand OOAC biology, let alone extrapolation of this to clinical significance. Additional interpretive steps will be required to establish in vitro to in vivo translation, including how to compensate for 'missing' organ functions in the connected networks. Also, due to an absence of available data, the issue of models only ever being 'semi-validated' will need to be overcome. Overall, a framework needs to be built such that translational success and failures can be shared to help understand the ultimate value of OOAC technology and deliver the necessary 'gain of confidence'.

Wang et al., 2014, Nat Med 20(6) pg. 616-623.
Huh D, et al., 2010 Science 328:1662-1668.

UK regulatory view of OOAC technologies
David Jones, *MHRA*

The inadequacy of current drug testing paradigms, especially in toxicity testing using animal models, has encouraged the development of humanised cell models as an alternative for safety assessment. The application of human-based OOAC approaches may yield products progressing into human clinical trials with improved safety and efficacy profiles. As such, OOAC offers promise but requires validation and improved translational understanding. This is challenging as systems do not yet fully recapitulate human organ physiology (e.g. they lack endocrine and immune responses), and toxicity and human disease processes are not fully understood in vivo.

Despite these challenges, the regulatory authorities see potential in OOAC technology and regulatory routes to validate cell models already exist e.g. the European Centre for the Validation of Alternative Methods (ECVAM), although the timelines are long. Regulators encourage sharing of supportive data from unvalidated models when testing these novel approaches alongside existing methods to demonstrate potential utility. This will not be part of the regulatory decision-making processes. Additional challenges around interrogating the small volumes found in OOAC systems, asking specific questions and setting realistic goals for the capabilities of the OOAC platforms are essential to deliver decision-making data. This is best achieved by collaboration across the sector and with regulatory agencies.

Development and qualification of OOAC – fit for purpose?
David Hughes, C*N Bioinnovations*

To build a successful OOAC assay, a phenotype needs to be measurable, a pharmacological response demonstrable, and the system useable and practical. Many formats exist for toxicity and efficacy testing with increasing complexity generally dictating reduced robustness. At CN Bio, progressive development from single cell liver chips (with hepatocytes) and mixed cell populations (hepatocytes, stellate and Kupffer cells) has been established enabling disease modelling. Examples of this include Non-Alcoholic Steato Hepatitis (NASH) and productive systems for the Hepatitis B Virus (HBV) life cycle. Effective qualification of the models and technologies, and demonstrating that they are fit for purpose, will be key to their success. Important questions to answer will be: Do the limitations of the devices apply constraints that may hamper interpretation to clinical relevance? How can donor-to-donor variability of primary-derived tissues in the platform be accommodated?

Usability is an important practical issue as it directly affects the testing of appropriate numbers of relevant annotated compounds. Communities are now establishing these test sets, which will help cross-platform interpretation and qualification. To advance the field, the National Institutes of Health (NIH) has established tissue-chip testing centres in the USA. These centres will independently deliver data from various platforms to corroborate manufacturer claims and stimulate wider acceptance and use of these approaches. Regulatory agencies such as the Food and Drug Administration (FDA) have also started to evaluate these technologies.

Workshop presentation summaries

Establishment of a UK OOAC community

Prof Hazel Screen, *Queen Mary University*

Recognising the growing importance of the OOAC sector the MRC, Engineering and Physical Sciences Research Council (EPSRC) and Biotechnology and Biological Sciences Research Council (BBSRC) have committed £500K over three years to develop and stimulate a UK OOAC network as part of the Technologies Touching Life Initiative. The network is developing with representatives from academia, industry, CROs, SMEs and technology vendors. The aims of the network are to:

- Develop and bring together a vibrant UK research community
- Facilitate research collaborations
- To inspire, train and support the next generation of industry-ready technologies, models and scientists

The inaugural meeting took place on 7th September 2018 at the BioMedEng conference in London.

Visit organonachip.org.uk for more information.

The 3DBioNet network (another Technologies Touching Life funded initiative) was discussed, highlighting the potential opportunities and synergies that may exist. This network consists of physicists, chemists, mathematicians, biologists and biomedical scientists progressing innovative 3D cell biology approaches for basic research and drug discovery in this multidisciplinary network.

Overview of industry needs for OOAC technologies and on-chip assessment of large molecules

Adrian Roth, *Roche*

Driving drug discovery using models with enhanced relevance to humans is highly desirable and will be hugely impactful. It will enable decision-making by delivering quantitative data and helping to solve issues from animal studies. A key need is looking beyond the simplest possible model, being able to measure chronic effects, testing in-aged cells and ensuring relevant model stability over time. One approach underway at Roche is to blend safety, disease pharmacology and efficacy in an integrated way to establish an in vitro therapeutic index (TI) using translational biomarkers. The challenge is not to simply add more supportive in vitro tests earlier, but to develop approaches like in vitro TI that may accelerate discovery. For example, by retiring pilot studies and enabling progression directly to GLP studies. For industry, sourcing and using primary human tissue is also a challenge and iPSC are not yet ready to act as equivalents, except perhaps in rare genetic diseases. The absence of an immune component, limited metabolic effects and poorly vascularised models are some barriers currently limiting the utility of OOAC models.

For large molecule discovery, methods to address challenges in this space are in progress with OOAC developers, including:

- Binding
- Biotransformation
- Aggregation
- Cell uptake
- Anti-drug antibodies

Two late stage examples of the recapitulation of clinically-relevant events on-chip were described. For hepatotoxicity, T-cell activation and invasion into hepatic tissue was demonstrated on chip. In addition, off tumour target mediated killing driven by T-cell recruitment from the blood into a lung compartment was described. In each case, both models were challenging to establish and validate (e.g. understanding receptor expression levels in vitro and in vivo) and to demonstrate the required gain-versus-cost-justification to secure the required resources. Overall, there is excitement and interest at Roche in further developing the OOAC systems by using in vivo-derived knowledge of biology and recapitulating on chip. Roche's therapeutic portfolio is moving towards complex large molecules, which is driving the development of more sophisticated cell models impacting multiple cellular pathways.

Overview of industry needs for OOAC technologies and on-chip assessment of small molecules

Lorna Ewart, *Drug Safety and Metabolism, IMED Biotech Unit, AstraZeneca*

The added value anticipated from OOAC approaches from in vitro patient models cuts across drug discovery from target identification and validation, and problem-solving. This will reduce in vivo reliance and refine in vivo study designs. Reducing the amount of compound from that required for an animal study is also another potential positive effect. Whilst limited, throughput of OOAC technology may be generally viewed as a concern. Perhaps better models coupled with the integration of artificial intelligence may make high-volume screening approaches redundant in the future. At AstraZeneca (AZ), opportunities and challenges have arisen from the multiple OOAC systems currently being used. In one example, patient-derived hepatocytes cultured as spheroids demonstrated a format-specific paracetamol toxicity for various liver markers that was not seen in other hepatocyte models. Similarly, the importance of context of use was highlighted in a bone marrow toxicity application, where compound effects on specific lineages of bone marrow stem cells was demonstrated. On-chip metabolic detoxification by the liver for the cardiotoxic drug, terfenadine, showed that the QT interval effects were driven by liver Cytochrome P450s (CYP) activity. The ability to discriminate between effects on contractility and field potential duration provided a good example of an integrated OOAC test system with 'on board' detection technology. Teams at AZ and CN Bio are working together to investigate the potential therapeutic activity of compounds in fatty liver diseases. The two teams are co-developing a model using relevant primary cell types in a device from which cytokine arrays will be measured to assess the degree of pathological equivalence and fingerprinting the effects of test compounds. Challenges were described, covering:

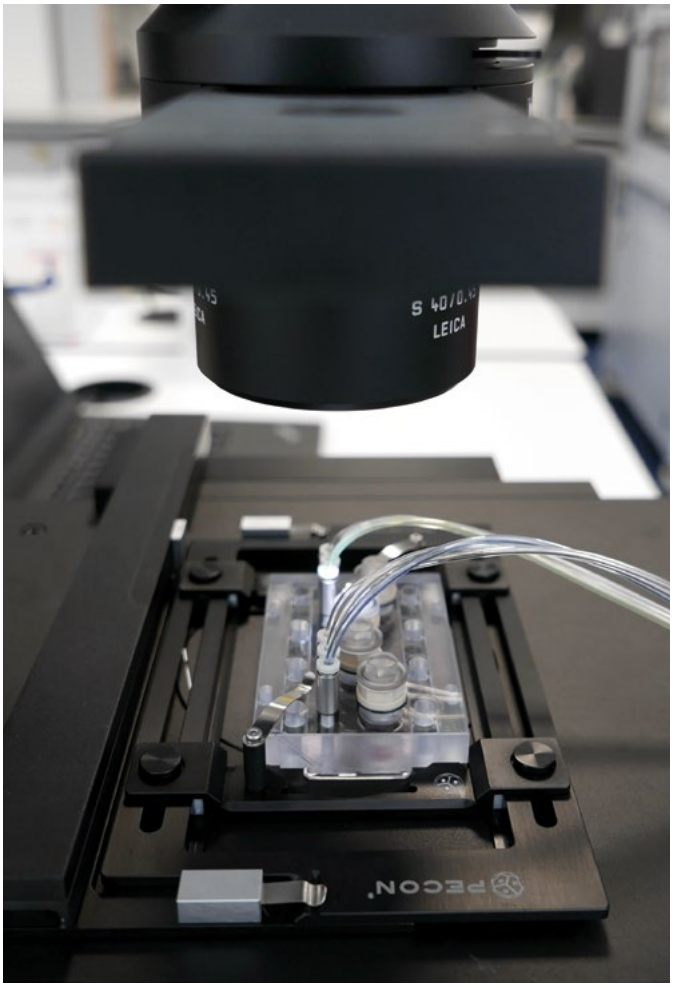
- Polydimethylsiloxane (PDMS) compound binding
- Access to quality and well-characterised primary cells
- The lack of harmonisation and multiple vendor systems
- The inadequacy of stem cells

The need to engage with regulators and establish wider community partnerships were also an output from the AZ team's work and reflections from actively using OOAC systems.

Role of CROs in accelerating and broadening the adoption of technologies

Clive Roper, *Charles River*

Multiple companies are active in 3D cell models, organoid manufacture and provision, bioprinting and engineering aspects of OOAC technology. The CRO community can help in the acceleration of the adoption of OOAC and other technologies, given their position as a gateway for pharmaceutical company demands and a route to market for innovators. Expectations from the pharmaceutical industry continue to grow for CROs to deliver complete solutions and to innovate in new areas. CROs can stimulate the innovators, particularly when multiple needs are collated and presented to an innovator to derive new products. Similarly, CROs may enable or trial the introduction of a technology to address an industry need where the innovator is unable to run the test. Partnership, communication and collaboration are essential across all the participants to synergise the development and evaluation of OOAC technology.



Discussions from the workshop

Discussions from the workshop were grouped into three areas:

- Development of a UK OOAC network
- Funding requirements
- Scientific and technical challenges and opportunities

Development of a UK OOAC network

There is a strong desire to build and shape the newly established UK OOAC network, bringing representatives together from across the community. Tools need to be in place to help visibility of cell models, technologies and scientific capabilities. A searchable UK database (building on activity at Medicines Discovery Catapult) as well as accessing skills and knowledge already captured from the UK OOAC network members would be a useful resource (Queen Mary University of London).

There are considerable limitations with existing network initiatives in this space. For example, some are open only to pharmaceutical companies. Others are large, unwieldy and overly bureaucratic, making it difficult for them to react quickly to changes in the landscape; and many are yet to make their position known in the OOAC area. Therefore, an agile and OOAC-specific network addressing these issues is welcome in the UK.

Lessons could be learned from the agrochemical, petrochemical, tobacco and cosmetics industries around cell models and OOAC approaches. Encouraging representatives from these organisations to connect to the UK OOAC network is a potential option.

There is a strong desire amongst the community to support the growth and development of the UK OOAC network and to use the expertise within this to identify major hurdles and opportunities for realising the UK's potential in this space. A series of focussed workshops bringing together cross-sector and cross-disciplinary experience could be established to explore these in greater depths.

Funding requirements

PhD studentships for OOAC and model development were viewed as valuable with low co-funding requirements from Industry. The UK MRC, BBSRC and NC3Rs are encouraging grant applications in the OOAC areas, including co-funding across traditional boundaries.

Short-term funding placements via the UK OOAC community are a welcome addition to available options. These will likely be supporting lab exchanges, short-term embedding of scientists to learn new skills in a host laboratory etc. Additional details are now available online: organonachip.org.uk/funding/sabbaticalfunding/

Given the potential for OOAC technology to reduce reliance on animal models in basic and applied research, the NC3Rs supports and encourages applications in this space across its funding schemes. This includes its Skills and Knowledge Transfer Awards, which de-risk the translation and adoption of OOAC models (and other alternative approaches) through the transfer of knowledge, skills and expertise between research groups.

Policing of deliverables against successful grant funding was viewed as different in the USA compared to Europe. Governance was more stringent, and investigators are more held to account in the USA. This is a risk for future funding. The NC3Rs CRACK IT Challenges were cited as a UK example that was good in this space, well-managed, with specific problems and progression reviews.

Scientific and technical challenges and opportunities

The ultimate success for the OOAC approach relies on the quality and relevance of the cells or tissue, and on the ability to support these in micro-engineered devices. More activity and investment in complex cell models is necessary to understand and minimise the inherent compromises in the utility of the models. The drug development community is not calling for 10 organs on a chip at this point. The community is looking for well understood single mixed-cell models combined with flow, supporting matrix etc., and limited (two or three) connected models. Characterising these simpler systems will better serve technology, utilisation and reproducibility studies. The features of OOAC technology that are necessary to achieve sufficient organotypic function are not universally agreed. An IQ initiative is underway to specify the required functions for the main human organs on a chip. This output is eagerly anticipated and needs to be disseminated to the cell model developer community.

There is good evidence of overcoming technical challenges around microfluidics, as evidenced by the Defence Advanced Research Projects Agency (DARPA) human-on-a-chip program in the USA. However, there is a plethora of platforms which hampers understanding across and between non-interoperable systems. The chip developer community is small in the UK, but the willingness to share is high. These innovators are strongly encouraged to not 'reinvent the wheel' for microfluidic systems and dilute resources. This issue may be overcome by improved communication across UK & Europe, as one success of the DARPA initiative has been to build a community that has a better awareness of each other's activities.

For increased knowledge and adoption of the technology, use-case examples should be shared widely. For efficacy-based projects these activities are short-term needing a rapid turnaround. Contrast this to toxicity, where representative models will continue in perpetuity and will have a more impactful ROI. Of course, off target models are more challenging to develop, so an interim solution of specialising in a particular toxicity area is more achievable. These pathfinder studies will be beneficial to further understand the value of OOAC technology and its application and impact.

The OOAC community must be aware that there is the potential to drive research towards poorly predictive and non-representative model systems. These may well be highly contrived and add little beyond existing in vitro or animal models. For example, the complexity of co-media requirements needs to be addressed and optimised for multiple connected organs, to maximise opportunities rather than constrain these models. Nevertheless, progression of supportive data from unvalidated models is encouraged by the MHRA to facilitate knowledge about and utility of this technology.

There is a call for enhanced on-chip detection technologies to assess dynamic biology – biosensors that are label-free and real-time to capture more sophisticated outputs from the OOAC platforms, measuring biomarkers with aligned clinical relevance.

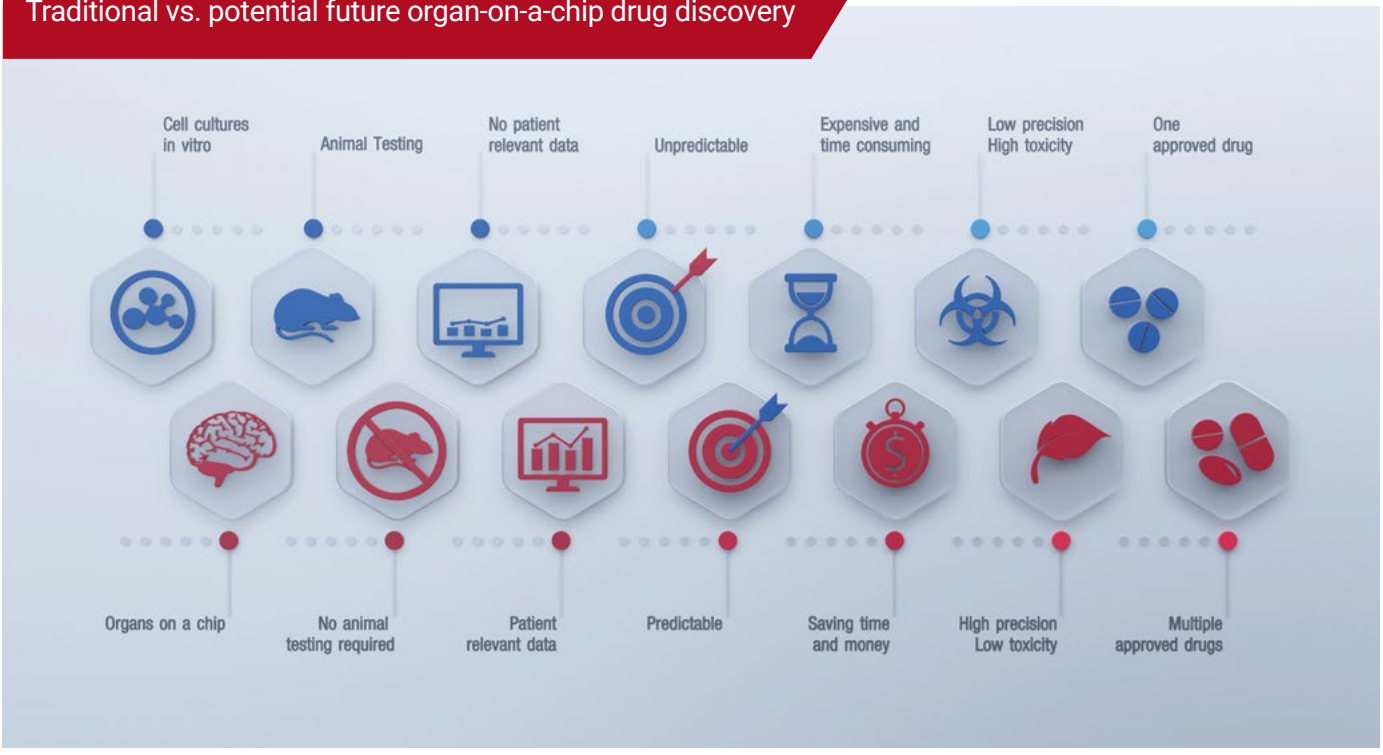
Qualification of systems is challenging due to comparison across formats and variable compound testing lists. In vitro to in vivo extrapolation and species differences present challenges when looking at correlations between preclinical models and humans. Is there a place for animal-on-a-chip to help resolve these issues? Does any data already exist from the agrochemical and petrochemical industries?

Access to patient-derived samples for complex model development is challenging. Lowering this barrier and enabling better knowledge of sample associated data and ethical positioning are required. Several organisations, including the UK OOAC network, Medicines Discovery Catapult, and the NC3Rs are addressing these issues.

Conclusion

The potential of OOAC technology to impact across multiple areas of academic research and industrial drug discovery is driving the enthusiasm and investment in on-chip microfluidics and new approaches to cell model development. Representative, robust and reliable on-chip organotypic functions and their inter-communication may stimulate improved success from target identification through to clinical approval by replacing poorly predictive animal models, with more physiologically relevant human-based models during drug development. The skills to maximise this technology and deliver true patient benefit are multi-disciplinary. The UK is well positioned to progress these approaches by innovating across technical, funding and regulatory boundaries guided by a communicative, dynamic and representative network of OOAC innovators, users, regulators and funders.

Traditional vs. potential future organ-on-a-chip drug discovery



Appendix 1: Agenda

Organ-On-A-Chip Technologies: Current status and translatability of data

Date: 15th May 2018

Place: Sensor City, 31 Russell Street, Liverpool, L3 5LJ

Organising committee: Malcolm Haddrick *Medicines Discovery Catapult*; David Jones *MHRA*; Anthony Holmes *NC3Rs*; David Hughes *CN Bio*; Adrian Roth *Roche*; Mark Holbrook *VAST Pharma Solutions*; Neil French *CDSS*; Alan Norris *CDSS*

08.30-09.00	Registration and coffee	Chair: Munir Pirmohamed *CDSS, University of Liverpool*
09.00-09.10	Welcome, overview of the MRC CDSS and workshop aims	
09.10-10.00	Broad overview of organ-on-a-chip technologies and utilities	Gianni Dal Negro *GSK*
10.00-10.30	Discussion	
10.30-10.50	Break	
10.50-11.20	OOAC translatability successes and challenges	Malcolm Haddrick *Medicines Discovery Catapult*
11.20-11.30	Discussion	
11.30-12.00	UK regulatory view of organ-on-a-chip technologies	David Jones *MHRA*
12.00-12.10	Discussion	
12.10-12.40	Qualification of systems	David Hughes *CN Bioinnovations*
12.40-12.50	Discussion	
12.50-13.30	LUNCH	
13.30-13.40	Overview of industry needs for organ-on-a-chip technologies	Adrian Roth *Roche*
13.40-14.05	Industry case study (1) – organ-on-a-chip assessment of large molecules	Adrian Roth *Roche*
14.05-14.15	Discussion	
14.15-14.40	Industry case study (2) – organ-on-a-chip assessment of small molecules	Lorna Ewart *AstraZeneca*
14.40-14.50	Discussion	
14.50-15.05	The role of CROs in accelerating and broadening adoption of technologies	Clive Roper *Charles River*
15.05-15.10	Discussion	
15.10-15.30	Break	
15.30-17.00	General discussion: how do we generate pivotal/translatable data and catalyse progress through partnering efforts of vendors, pharma, regulatory and funders?	Chair: Malcolm Haddrick *Medicines Discovery Catapult*

Appendix 2: Workshop attendees

Company	Delegate name
Alcyomics	Shaheda Ahmed
AstraZeneca	Lorna Ewart
Bayer	Marian Raschke
Certara	Iain Gardner
Charles River	Clive Roper
CN Bio Innovations	David Hughes
Cyprotex An Evotec Company	Paul Walker
Envigo	Robert Guest
GSK GlaxoSmithKline	Gianni Dal Negro
Kirkstall	Bhumika Singh
Catapult Medicines Discovery	Malcolm Haddrick, Sally Price
Mimetas The organ-on-a-chip company	Jos Joore
MHRA	David Jones, Maria Beatrice Panico
NC3Rs National Centre for the Replacement Refinement & Reduction of Animals in Research	Cathy Vickers, Sam Jackson

Company	Delegate name
Orion Pharma	Satu Juhila
Roche	Adrian Roth
Servier	Yannick Parmentier
UCB	Reiner Class
MRC Centre for Drug Safety Science	Munir Pirmohamed, Neil French, Chris Goldring, Alan Norris, Michael Cross, Carrie Duckworth, Parveen Sharma
Queen Mary University of London	Hazel Screen
University of Liverpool	Joe Leedale
University of Cambridge	Gianmarco Mastrogiovanni
The University Of Sheffield.	Kai Erdmann
Vast Pharma Solutions	Mark Holbrook
Innovate UK	Gordon Ford, Richard Hebdon
MRC Medical Research Council	Megan Dowie
BBSRC bioscience for the future	Luke Williams

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