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

Microphysiological systems (MPS)

What are microphysiological systems?

Microphysiological systems (also known as MPS) are experimental platforms that enable living cells or tissues to be maintained in a laboratory. Examples of MPS include organ-on-chip technologies where miniature tissues are grown inside polymer chips and perfused with fluids, and organoids, which are 3D tissue structures grown from stem cells. MPS aim to recapitulate the key features of the organs they represent and can provide an accurate model human physiology. They provide an alternative to using animals in research and can be used to study:

- Organ function
- Disease
- Drug discovery
- Drug efficacy
- Toxicology

Why are MPS important?

Experiments to understand human biology and test new drugs have traditionally been performed in either simple laboratory cell culture models or in animals. These often fail to reproduce human biology and experimental results do not always successfully translate to improved outcomes in patients. Animal models also present practical issues including long experimental times and high associated costs as well as ethical concerns about animal welfare. MPS allow researchers to ask experimental questions within models that do not require the use of animals and can often more accurately replicate human physiology, providing a significant opportunity to replace animals in scientific research.

Key developments in MPS

MPS first emerged in the early 2010s as a way to move beyond simple cell culture to better recapitulate tissue complexity in the laboratory. Early models focused on introducing flowing fluid to cultured cells to mimic the interstitial fluid that passes over cells in the body and create a more physiologically relevant environment. Evolution of MPS has been driven by advances in areas such as 3D bioprinting and tissue engineering. These have allowed the development of models which have the capacity to assess biological responses at an organ level. MPS are continuing to increase in complexity and next generation MPS where multiple organ

models in distinct chambers are connected by fluid resembling blood will enable the study of intra-organ interactions and provide a greater insight into disease biology.

MPS is a rapidly growing area. For example, for the global organ-on-a-chip field, the market was valued at $103M in 2020 and is projected to reach $1.6BN by 2030, growing at a mean annual rate of 31.1% from 2021 to 2030[1].

Given the importance of MPS for replacing animal use, the NC3Rs has invested £28.6M in 128 MPS projects*. These focus on four main areas:

- **Development of new MPS technologies** for a range of scientific and biomedical purposes where animals would otherwise be used. These include models to study the biology of healthy and diseased tissues, models to study cancer development and progression and models for drug toxicity screening.
- **Transfer of established MPS technologies** between laboratories for wider adoption that helps build confidence in using these new systems. Models may be transferred between laboratories studying similar research topics or may be adapted for use in different research areas.
- **Commercialisation of MPS technologies** so that they are readily available to researchers. Developing and using MPS models for use in drug development is of high importance to the pharmaceutical industry and has the potential to lead to improved translation of results from drug testing in the laboratory to patients.
- **Overcoming barriers to uptake of MPS**. These include compatibility with existing laboratory equipment such as microscopes and incubators, the cost of purchasing new equipment and requirements for specialist training to establish these technologies in individual laboratories. Some MPS technologies require further development and validation to ensure that they are fit-for-purpose for the context in which they will be used. The NC3Rs is committed to overcoming barriers to uptake through funding research and innovation and ensuring new technologies are efficiently disseminated to end-users. For example, the 2021 international NC3Rs prize was awarded to Dr Daniel Ferreira at the Instituto de Investigação e Inovação em Saúde, Portugal for his work constructing microfluidic chips from commercially available sheets of thin polymer. This reduces the cost and time required to manufacture MPS devices, removing key barriers to uptake.

*Document last updated: March 2023.

[1]Allied Market Research (2022). Organ-on-Chip Market. Opportunities and Forecast 2020-2030.