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Artificial mini organisms instead of animal testing

Everyone wants medication – we're not talking about animal testing here. Up to now, this has been a necessary evil in medical research. Microphysiological systems, in which organs and organ systems are "created" are a promising alternative. Therewith, complex mechanisms of the human body can be realistically analyzed. Among other things, these microsystems contain ducts, reservoirs, actuating elements, sensor technology and 3D scaffols "made by laser". The Fraunhofer IWS offers partners from the fields of biology and medicine complete solutions for microsystem technology – from design to prototype, including the automation system.

Animal testing has long since been extremely controversial discussed for lots of good reasons. On the one hand, there is the ethical dubiety of animal testing in itself. On the other hand, many scientific studies have reported considerable deficits in the transfer of the results to humans. This then causes serious side effects during clinical trials on humans. This is why many doctors, scientists and, of course, patients want to find alternative technology, which can predict the complex processes caused by the absorption, distribution and effect of medications and cosmetics in the human body. Frank Sonntag from the Fraunhofer IWS has been working on a solution to this problem since 2010:

"The microphysiological systems developed at the Fraunhofer IWS are miniaturized cell culture systems the size of a business card, which reproduce the pharmacologically relevant functional mechanisms of the human body. As well as the distribution of substances through a network of vessels, this also includes the microphysiological environment of somatic cells and the interaction between different cell types. Thus, the biochemical and cellular procedures of the human body's organs can be reproduced. This is necessary to replace complicated pharmaceutical tests, which currently take place through animal testing."

In specific terms, researchers are mimicking the function of the organs and organ systems through the joint cultivation of several human cell types in the microphysiological system. As in the human body, different cell types need different conditions to fulfil their specific functions. The task of the developers at the Fraunhofer IWS is to develop customized microphysiological systems for various organs on the chip, thus contributing to a reduction in animal testing. Important body functions, such as the constant regulation of temperature at 37 °C, are provided in all microphysiological systems using technical solutions such as heating and cooling elements. The special feature of the microphysiological systems developed at the Fraunhofer IWS is a miniaturized pump, which is based on the human heart. Powered by a special controller, blood-like cell culture medium is circulated in the artificial capillary network, ensuring cells are cultivated at optimal levels of oxygen and nutrients. The size of the artificial capillary network can be calculated using mathematical models. Mathias Busek is currently writing his thesis at the Fraunhofer IWS and developing flow models of microphysiological systems:

"The simulation of the flow and nutrient transport into the microfluidic capillary network helps us to ensure demand-based supply of the cultivated cells, therefore supporting the formation of organotypical functions. With network models, these calculations can be

done quickly and reliably and are a valuable tool in the design and optimization of microphysiological systems".

The developed microphysiological systems are used by many partners in research and industry. The uses range from individual organ structures in one microphysiological system to many organs in a "multi-organ-chip". At the University Hospital Dresden, Jan Sradnick and Deborah Förster, together with Florian Schmieder from the Fraunhofer IWS, have developed a microphysiological model of the renal capillaries. This allows important disease processes of the kidneys to be reconstructed without the use of laboratory mice, thus reducing animal testing in basic research. The researchers are currently developing a complete cellular model of the kidneys. The microphysiological systems for this are being designed by Florian Schmieder at the Fraunhofer IWS:

"To investigate the entire kidney in the microphysiological system, rather than just subprocesses, we are currently developing a model, which reconstructs all the functional parts of the kidney at cellular level. While the investigation of renal diseases is currently the most important use, such artificial organs can be used as artificial kidney replacements in the future by seeding the patient's own cells into the artificial structures. This would be a real alternative to dialysis and donor organs and would provide a decisive contribution to improving the life situation of many patients."

Even though the systems developed at the Fraunhofer IWS already help to answer complex, biomedical issues, extensive research is still required until the vision of artificial kidneys and a sustainable switch to research using non-animal testing becomes a reality. In December 2016, the Dutch government presented an extensive policy paper, creating a legal, social and financial framework for developing alternative models to replace animal testing by 2025. The Fraunhofer researchers hope that such a comprehensive paradigm shift will also be applied in Germany soon. This is the only way visions such as research with non-animal testing and the production of artificial organs can become a reality.

Frank Sonntag has been developing microphysiological systems to replace animal testing since 2010.
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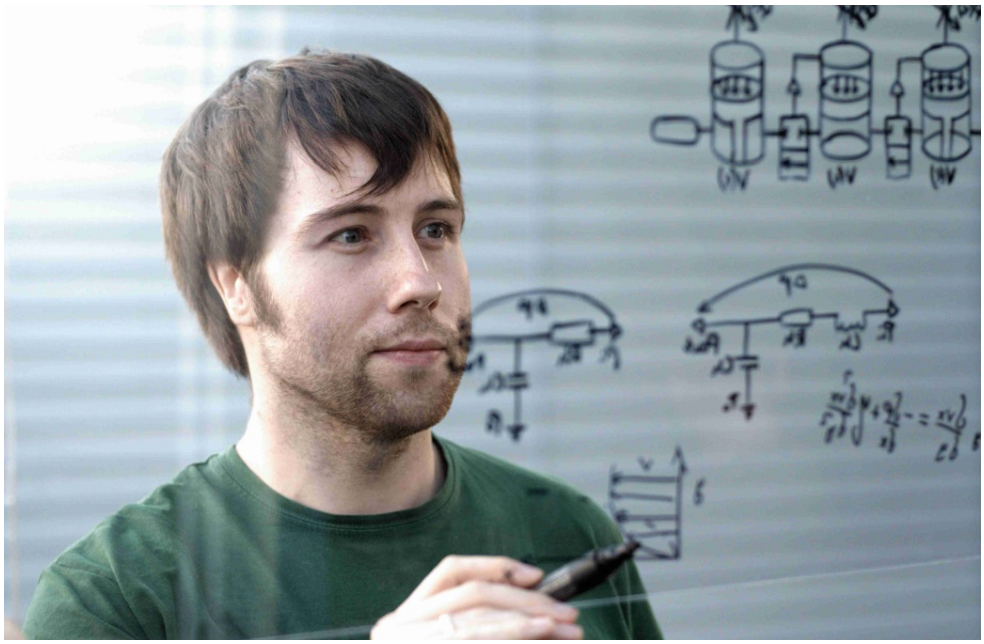

Mathematical models are helping Mathias Busek to optimize the flow behavior in microphysiological systems, so that organotypical cell bonds can be formed.
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Florian Schmieder, Deborah Förster and Jan Sradnick (from left to right) are developing a microphysiological model of the kidney. As a result, they are creating the basis for artificial kidney replacement from patient's own cells.
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