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Preface

Stem cell based human organ-on-a-chip models for drug discovery and development

Drug discovery and development today is hampered by high failure rates, which can be extremely cost-intensive in particular if occurring during late clinical phases. Hence, there is an urgent need in pharmaceutical industry to effectively and efficiently screen potential drug compounds to assess both efficacy and safety already during early stages. Current high failure rates can be attributed to the reliance on non-human animal models and non-physiological cell assays employed during pre-clinical safety and efficacy testing. The advent of human induced pluripotent stem (hiPS) cells has led to the emergence of a new paradigm of drug screening by directly testing on various types of human cells, including those critical for drug screening and toxicity testing as well as the screening on patient and disease-specific systems. In recent years, a variety of perspectives, reviews, and special issues focused on the use of stem cells for drug development, such as "Pluripotent stem cells in disease modelling and drug discovery" by Avior et al. [1], "Induced pluripotent stem cells—opportunities for disease modelling and drug discovery" [2] by Grskovic et al., and "Integrating human pluripotent stem cells into drug development" by Engle and Puppala [3]. However, arguably the greatest disruptive potential of the discovery of hiPS cells comes from our new-found ability to create human organ-like tissue cultures *in vitro*. One promising approach to produce these organ-like structures is the organ-on-a-chip, also called microphysiological systems, technology. These microfluidic platforms are capable of providing physiological environments with in vivo-like biomechanical properties and a vasculature-like perfusion. Integration of human tissues in these platforms generates human *in vitro* models of organs with *in vivo* structure and function [4,5]. Yet, the access to (healthy) human cells and tissues has traditionally been a major challenge for many organ/tissue types. Now, the hiPS cell technology provides the tool needed to overcome this challenge.

Leveraging the breakthrough combination of hiPS cells and organ-on-a-chip may potentially lead to a paradigm shift in pharmaceutical and biomedical research. This theme issue of *Advanced Drug Delivery Reviews* therefore focuses on the prospect of stem cell based human organ-on-a-chip models for drug discovery and development. In the issue, a variety of experts from the two fields provide an overview of the current state and future challenges of stem cell based models of various tissues and their applicability for drug discovery and development. Wu and colleagues introduce the progress, obstacles, and limitations that currently exist for the use of stem cells in organ-on-a-chip models [6]. Villenave, Nawroth and colleagues contribute a review on stem cell based lung-on-a-chip models [7], while Liebau and colleagues focus on stem cell based retina models [8]. Other articles assess the potential of combining hiPS cell technology with liver-on-a-chip research (Mosig and colleagues [9]) and with vascular biology (Van der Meer and colleagues [10]). Chramiec and Vunjak-Novakovic focus their review on tissue engineered models of healthy and malignant human bone marrow [11] and Zimmermann and colleagues explore heart tissue-on-a-plate models [12]. Going beyond modeling of individual tissues, Schenke-Layland, Loskill and colleagues compiled a comprehensive overview on how diabetes research could benefit from stem cell based organ-on-a-chip models [13]. Last but not least, Ewart, Fabre and colleagues provide an end-user perspective on the potential of combining microphysiological systems with induced pluripotent stem cells by looking at blood brain barrier research in a pharmaceutical setting as a case study [14].

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