Book Review

Edited by Paul H. King

Organ-on-a-Chip Engineered Microenvironments for Safety and Efficacy Testing

Edited by Julia Hoeng, David Bovard, and Manuel C. Peitsch,
Academic Press, 2019,
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xx + 523 pages, $135 (web Jun. 6, 2020)

The need to improve testing platforms for current and new pharmaceuticals has helped generate studies involving "organs-on-a-chip" technologies in recent years. This text, aimed at a readership including biomedical engineers, entrepreneurs, design engineers, new drug investigators, etc., attempts to survey the current state of the art in this area of endeavor. It does this well, with 15 chapters from 36 contributors from eight countries. The text covers the many justifications for this work, multiple examples of platforms involving one or more lines of organ cells, discussion of the technologies involved in system design, and one chapter giving an example of a multi-organ-on-a-chip design.

Three initial chapters serve to introduce the basics for this text. The first covers the perceived needs for this technology, which are presented as primarily being: 1) to decrease or replace the need for testing in animal models, due to the associated ethical questions (think PETA in the USA) and the fact that animal models do not necessarily predict human reactions and 2) the cost (both time and money) for testing is currently very high for most new drug developments and must be decreased to enable more and faster new drug development and testing. The second chapter overviews cell sources (including immortal, cancerous, and normal human organ cells), and lists vendors for these cells and chip components. A brief discussion of bioprinting methods is included. A third chapter overviews the engineering considerations in design of the system(s) for organ containment, sensing, nutrition, etc.

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Eight chapters follow under the subheading: "Part I Organ-on-a-chip platforms to model disease pathogenesis." Six chapters cover, in turn, lung, liver, brain, kidney, heart, and gut on-a-chip. Each chapter covers, briefly, the basic physiology of the organ, the number of cell types in the organ (and the number most often used), essentials regarding chip design, uses for the chips, and a discussion of the state of the art. The seventh chapter gives an overview of pharmaceutical modeling using organs on a chip, with an reiteration of the fact that currently 95% of all drugs currently fail without an end use, thus organ-on-a-chip modeling is needed with the hopes that this will improve *in vivo* tests and utilization. A dramatically different eighth chapter covers the use of C-elegans on a chip for high throughput testing of hundreds of animals in serial or parallel test modes.

A final four chapters are included under the subheading "Part II Multi-organs-on-a-chip platforms to mimic humans physiology." Chapter 12, titled "Design and engineering of multiorgan systems" gives an overview of design considerations for organ-on-a-chip systems that include any from 2 to 14 interacting organs, such as liver and heart cells, liver, and lung. These multi-organ systems are mandated when studying compounds where the output of one organ (e.g., the liver) due to the compound influences another organ (e.g., kidney.) Also covered in this chapter are guidelines for scaling and interconnecting the various organ-on-a-chip systems. Chapter 13 reviews the need for, and several attempts at, "Human body-on-a-chip systems." Attempts discussed include the female reproductive system and a diabetes model (liver/pancreas).

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Overall goals of the work include not only the study of "body-on-a-chip" (general physiology studies) but also "patient-on-a-chip" studies for a specific individual. Chapter 14 reviews the need for, and current attempts at automating the entire process of "organ-on-a-chip" studies. The need to transition from current academia (human labor intensive) to industry automation and scale-up is well justified here. The final chapter (15) gives an overview of the steps needed to build a multiorgan (lung/liver) organ-on-a-chip system. The reader is taken through the entire process, from the initial design questions posed, to requirements generation, functional analysis, process diagraming, subsystem design, and test/validation.

As a carnivore, when reading this text, I wondered if lessons learned from current attempts to "grow" meat could be applied to some of the work herein. (See, for example, "The race to make cell grown meats mainstream," *Popular Mechanics*, July/August 2020, pp. 44–51.) As a (retired) design instructor, having had the experience of having had students working on organ-on-a-chip devices for their senior projects, I find this book to be very up to date and a good overview of the field. As a reviewer, I recommend this text for use in introducing new investigators and entrepreneurs to this field of applied work in physiology and toxicology. ■

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