# THE MECHANICS OF THE CIRCULATION

SECOND EDITION

Continuing demand for this book confirms that it remains relevant over 30 years after its first publication. The fundamental explanations are largely unchanged, but in the introduction to this second edition the authors are on hand to guide the reader through major advances of the last three decades.

With an emphasis on physical explanation rather than equations, Part I clearly presents the background mechanics. The second part applies mechanical reasoning to the component parts of the circulation: blood, the heart, the systemic arteries, microcirculation, veins and the pulmonary circulation. Each section demonstrates how an understanding of basic mechanics enhances our understanding of the function of the circulation as a whole.

This classic book is of value to students, researchers and practitioners in bioengineering, physiology and human and veterinary medicine, particularly those working in the cardiovascular field, and to engineers and physical scientists with multidisciplinary interests.

'. . . essential reading for anyone who is interested in the mechanics of the circulation. The normally incomprehensible mechanical laws are explained so clearly that even the non-mathematically minded will have no difficulty, which makes me very sorry that it was not available when I was grappling with these problems.'

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'Like a good sculpture which leaves no chisel marks on the marble, there are no marks of individual specialization in this book. All is well integrated toward the physiology of circulation . . . After reading the book, one would wonder how can circulation physiology be understood without such a study of mechanics. It cannot! I recommend this book to all physiology teachers and students.'

Y. C. FUNG, Journal of Biomechanical Engineering

'Here is a book on the mechanics of the circulation that is equally accessible to those trained in the life sciences and in the mechanical sciences.'

SIR JAMES LIGHTHILL, Journal of Fluid Mechanics

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# Foreword

When I arrived at the Physiological Flow Studies Unit, Imperial College, in 1971, the writing of *The Mechanics of the Circulation* was already underway. The book had been commissioned by Oxford University Press to be delivered in 1972 and the Tuesday afternoon book meeting was a regular event. From the outset, the purpose of the book was seen as presenting cardiovascular mechanics in a rigorous but accessible way. It was not meant to be a textbook, but an introduction to the subject that would be useful to a wide range of readers from medical students to experts in either mechanics or cardiovascular physiology.

*The Mechanics of the Circulation* was finally published in 1978 and it was obvious that the authors had succeeded in their purpose. It was a truly interdisciplinary book, its authors having trained in medicine, mathematics and engineering, but there was a continuity of style and content that remains unusual in multidisciplinary, multi-author books. Individual authors wrote the first drafts of the different sections of the book closest to their expertise, but they all had an equal say in the final product which, as evidenced by the time it took to write the book and the heat that was generated in those weekly meetings, was no easy task.

The book had an enormous impact on the emerging field of cardiovascular mechanics and, by extension, on the development of the discipline of bioengineering as an essentially multidisciplinary field of study. It was reprinted and published as a paperback. Then, for reasons known only to the publisher, it was allowed to go out of print. In the years that followed there were occasional discussions about writing a second edition to incorporate the many advances that had taken place in the understanding of the cardiovascular system. But, because of other pressures and activities, the authors never found the time and the book became unavailable (except for the Russian and Chinese translations which continued to be available for several decades).

With the authors all retired, new discussions arose about a second edition and I was very honoured to be asked to be involved. We had many meetings about the changes that were needed and how the book could be made more relevant to the present time. It very quickly became evident, however, that the explosion of knowledge about the

physiology and mechanics of the cardiovascular system during the past 30 years made it impossible to embrace the whole subject in a single book. After much discussion, it was decided that the one thing that has remained constant over the years is the basic mechanics, which was the primary subject of the original book. We therefore decided to republish rather than rewrite the original book. This volume, with the addition of this foreword, a new preface, a few minor corrections and a greatly enhanced index, is the result.

Some flavour of the differences in research on the circulation between 1970 and 2010 can be gained simply by considering the way the old and the new versions of the book were produced. The original book was written in longhand and transcribed by a typist. Editing involved handwritten comments in the margins and the index involved annotated filing cards that were sorted by hand. The book was set by hand and the figures were reproduced using photolithography. The current book was prepared by scanning the original into a text file generated by an optical character recognition program. The text files were edited on a computer into a LaTeX file which generated the final format electronically. The output of the LaTeX program was edited via email and the new index was generated using the 'makeindex' function in LaTeX. Finally, a LaTeX-compatible printing press was used to convert the electronic form of the book into the printed hard copy. Every aspect of cardiovascular science has undergone a similar revolution.

In the compilation of a new, greatly expanded index for this volume, I have been struck by two things about *The Mechanics of the Circulation*: its completeness and its cohesiveness.

In the course of introducing the mechanics of the circulation, the book covers the anatomy and physiology of the circulation in considerable detail and even includes some examples of its pathology. There are, inevitably, some omissions. For instance, the extracellular material at the outer surface of endothelial cells receives only the most fleeting of mentions in Chapter 13 and is never named as the glycocalyx. And in the extensive discussion of waves in the circulation there is no mention of the water hammer equation that so conveniently relates changes in pressure and velocity. It is remarkable, however, how rare these omissions are given the breadth of material covered.

Even more impressive is the cohesiveness of the book. The authors have taken great care in the cross-referencing between the different sections. 'Part I: Background mechanics' provides a thorough grounding in basic mechanics, with extensive links to the application of these principles to the cardiovascular system. 'Part II: Mechanics of the circulation' deals with the different parts of the circulation in turn. Here the links are not only to the basic principles, but also to the other parts of the circulation with similar or opposing properties.

From my personal experience and from the experience of other colleagues working on the circulation, *The Mechanics of the Circulation* is a very valuable book. It

provides an introduction to mechanics for those trained in physiology, medicine and biology and an introduction to the anatomy and physiology of the circulation for those trained in mechanics, engineering and mathematics. Virtually everyone I know in the field has a well-thumbed copy on their bookshelf and many have used it as a basic text for both undergraduate and graduate courses.

Thirty years after its original publication, I am delighted that this classic book is once again being made available to experts and, most importantly, to students – the experts-to-be.

Kim H. Parker
July 2010