Biomedical Engineering for Global Health

Rebecca Richards-Kortum's pioneering work and teaching are captured in this motivating text written for non-science majors and biomedical engineers, inspiring them to engage in solving the global health issues that face us all.

Studying with *Biomedical Engineering for Global Health*, students will:

- begin to understand the medical, regulatory, economic, social, and ethical challenges facing the development of health systems;
- see how these constraints affect the design of new devices and therapies;
- learn through case studies, including cancer screening, imaging technologies, implantable devices, and vaccines; and
- read profiles of undergraduate students who have participated in international technology development internships in Africa.

Rebecca Richards-Kortum is the Stanley C. Moore Professor of Bioengineering at Rice University, where her research group is currently developing miniature microscopes and low-cost imaging systems to enable early detection of pre-cancerous changes in living tissue. In collaboration with colleagues at Rice University and the Texas Medical Center, she has developed a four-year multi-disciplinary education and training program that promotes engineering and engineering technology on a global scale. Prior to working at Rice University, Dr. Richards-Kortum was a Professor of Biomedical Engineering at the University of Texas at Austin, where she was elected to the Academy of Distinguished Teachers and received the Chancellor's Council Outstanding Teaching Award. She has also received many other awards, including being named a Piper Professor for excellence in teaching by the Minnie Stevens Piper Foundation in 2004, and receiving the Sharon Keillor Award for Women in Engineering (2004) and the Chester F. Carlson Award (2007) from the American Society for Engineering Education. In 2008, she was elected to the National Academy of Engineering.

"This beautifully written volume by Rebecca Richards-Kortum will inspire and empower the next generation of engineers to make global health their calling."
Thomas Kalil, UC Berkeley and Clinton Global Initiative

"This book will become the most influential biomedical text of our generation . . . No other book has made such a transformation of young scientists in such a short time."
Nicholas Peppas, The University of Texas at Austin

"This book is an excellent first step in educating engineers about medical problems in the developing worlds and ways in which bioengineers can make a difference."
Paul Yager, University of Washington, Seattle

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Biomedical Engineering for Global Health

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Dedication

To my mostly patient children, Alex, Max, Zach and Kate, and to their endlessly patient father, Phil.

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Preface

Biomedical Engineering for Global Health gives students a cohesive overview of how biomedical technologies are developed and translated into clinical practice. The text integrates the major diseases facing developed and developing countries with the recent technological advances and the economic, social, ethical and regulatory constraints which impact the development of new technologies.

Biomedical Engineering for Global Health is accessible to students from all disciplines. The text responds to student interest in the fields of bioengineering and global health. As the world becomes more interconnected, students seek more opportunities to learn about disease and health, and how science and engineering can be used to solve global health challenges. In a global context, the text introduces students to bioengineering, epidemiology, health disparities, and the development of medical drugs and devices. For introductory courses in bioengineering, global health, epidemiology or related fields, this text serves as a comprehensive overview of global health challenges and the methods to improve health and prevent disease. The text answers four primary questions.

1. What are the major health problems worldwide and how do these differ throughout the world?
2. Who pays to solve problems in healthcare and how does this vary throughout the world?
3. How can we use technology to solve world health problems?
4. How do new technologies move from the laboratory to the bedside?

Throughout the text, three major case studies are used to illustrate the development, assessment and global diffusion of new medical technologies, including development of new vaccines to prevent infectious disease, development of imaging technologies to improve early cancer screening and development of implantable devices to treat heart disease. The case studies and other examples help students understand the economic challenges associated with developing health systems. Frequent examples are used to contrast health systems in both developed and developing countries.

The text includes profiles of leaders in translational research to expose students to the variety of career paths taken by individuals with MD, PhD or MD/PhD degrees. Also included are profiles of undergraduate students who have participated in international technology development internships in four countries in Africa. Students can directly relate what they are learning in the text to the experiences of their peers. These profiles will help

young bioengineering or global health students understand the important aspects of their discipline in the context in which it is practiced.

Homework problems engage a broad audience in mathematical and graphical analysis of real biomedical data, as well as in writing about the social implications of technology development. In addition, a project assignment spans the text, guiding students through the design of a clinical trial to test a new technology. The project provides an opportunity for students to develop, expand and test their knowledge of subject matter in a global context. The project asks students to select a disease of global health significance that is of interest to them. Students research current medical technologies to diagnose or treat the disease, and the limitations of those technologies in a resource-constrained setting. Design constraints are outlined for a new technology to operate in a resource-limited setting. Finally students propose a new medical technology to diagnose or treat the disease which meets these constraints and design a clinical trial to test the technology.

To further engage students in real world problems, a series of interactive classroom activities have been developed to accompany the lecture materials for the course. These activities contextualize real global health problems so that students can better understand and begin to view problems and solutions simultaneously. Multi-media materials and connections to new accounts of scientific developments increase student engagement.

Instead of simply focusing on the study of science and technology, this text takes an engaging student-centered, contextual approach to the study of bioengineering and biotechnology. Unlike other similar texts, *Biomedical Engineering for Global Health* is designed for students from all disciplines. It places a strong emphasis on the need for new health technologies, the process of technology development and the impact of technology development in a personalized, global perspective. Understanding these processes is vitally important to students throughout their lives as they make decisions about their own medical care and contribute to discussion of public policy issues affecting healthcare throughout the world.