Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2014 Volume IV: Engineering in Biology, Health and Medicine

Introduction

Engineering technology is advancing at a rapid pace. With these advances new tools, assays and reagents are being proposed for applications in the basic sciences and medicine. What used to be separate, unrelated disciplines are now merging into an integrated, interdisciplinary field that relies on biological and medical understandings for creation of new therapeutic and diagnostic devices. In turn, the technology is feeding back into the basic sciences and medicine, enabling a better understanding of structure and function of the complex network of cells and tissues in the body.

For those reasons, the tools and methods of the engineering profession are now frequently applied and refined by students in the life and medical sciences. Significant historical examples demonstrate the importance of this feedback loop – in the field of diagnostics, exemplified by Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) and ultrasensitive sensors for glucose and blood chemistry. Examples in the field of therapeutics include nanoparticulate drug delivery, patches, surgical devices, surgical robotics, drug screening and development using high throughput machines.

A striking feature of this invigorated interdisciplinary effort is its increasing intensity aided now by the unprecedented accessibility to information and ideas made relevant within the framework of outstanding challenges and the need for medical breakthroughs and understandings of how cells, tissue, and organs function in health and disease. As a result, the public at large, including science students and teachers, are very interested. The important questions include: Can nanotechnology solve cancer? How can one develop a better diagnostic for early stages of cancer? Can robotic devices be controlled with the sufficient accuracy in remote regions of the world for surgical intervention? Can epidemics be predicted and what limits the efficacy of vaccines for communicable and non-communicable infections? These questions, associated with our current human condition, may find their best answers in the engineering discipline.

The curriculum units contained in this volume demonstrate excellent examples of engineering in biology and medicine. The objective of this collection is broad as it introduces engineering methods and technologies to the life and physical sciences. It also guides engineering solutions and innovation using biology and medicine. The individual units give very specific examples, which include: development of biomaterials for immunotherapy, new vaccines, drug development, monitoring and use of genetically modified foods, intervention or modulation of the microbiome, use of robotic systems, and nanotechnology applications in drug and vaccine delivery. The contents of this volume speak to two concepts: 1) The tunability of engineered synthetic systems can be exploited to design new therapies and diagnostics; and 2) The same devices, because of flexibility over fabrication in different ways, can be used to understand the biology and medicine in greater detail.

This volume reflects the hard work of eleven Fellows who have diligently – over the course of the seminar meetings at Yale – suggested and integrated seminar material into their units. The volume is a timely addition to an emerging interdisciplinary curriculum.

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