FOCUS: BIOMEDICAL ENGINEERING

Introduction

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The Yale Journal of Biology and Medicine (YJBM) publishes articles on basic science and clinical medicine. In this issue, we have identified a field that bridges these two realms. Biomedical engineering is a discipline that successfully brings clinical applications from the bench to the bedside by taking engineering principles and applying them to biological systems and clinical disorders. This nascent field seeks to use engineering as the bridge between basic engineering, biological sciences, and the clinical applications that are often considered the end product of such research.

In biomedical engineering, the first step is to identify a potential problem in a physiologic system that can benefit from tools outside of the realm of basic science or clinical medicine. In particular, biomedical engineering differs from most basic biological research in that it seeks solutions based on engineering principles.

Next, biological engineers define boundaries and variables associated with the defined physiologic problem. What are the potential weaknesses of various approaches? Are there current physiologic systems in place that can be utilized for other purposes?

In this vein, Padmanabhan and Gonzalez define the role of the extracellular matrix in neutrophil transmigration, a process that leads to inflammation. The understanding of transmigration, cellular matrices, and elucidation of their function is essential when considering drug delivery methods to inflamed tissues that utilize the neutrophil transmigration pathway and machinery. The hypothetical roadway leading to otherwise difficult-to-reach tissues is thus mapped; now engineers must utilize this infrastructure to facilitate drug delivery. Gavrilov and Saltzman describe another potential system that exploits an existing system: using siRNA to control gene translation. Such control can lead to desired and controlled outcomes in the cell, but as with other potential treatments born of biomedical engineering, siRNA treatments struggle with the problem of proper delivery. Gavrilov and Saltzman explore the knowledge and drawbacks of delivery methods for siRNAs and where the field is headed in attempting to enhance and target delivery. Doucet, Lam, and Griffin take this one step further in their description of the parameters for mimicking natural neuromuscular stimulation in order to promote...
repair in nerve-damaged muscles of stroke and spinal cord injury patients. Once again, we see the application of an engineering approach to fixing a clinically relevant problem.

Once the research boundaries have been identified, the researchers may attempt to computationally model the system, as Di Achille and Humphrey model intracranial aneurysms. These models have the benefit of displaying physical strengths and weaknesses of a system in an organized, significant, and non-invasive way.

The final step takes the biological, engineering, and computational aspects of research and combines them into a cohesive treatment with clinical applications. Dean, Udelsman, and Breuer define a method of tissue-engineered vascular grafts in pediatric patients that is able to utilize the body’s natural ability to heal in such a way to minimize scar tissue and maximize efficiency of graft transfer. Forrest explores a different approach and discusses transcatheter aortic valves used to mimic and replace heart valves in patients with the hope of improving the health and lives of patients with aortic stenosis.

The articles in this focus topic represent snapshot images of fields of study at various phases along the spectrum from basic research at the bench to relevant applications in the clinic. Biomedical engineering is a discipline that focuses on treatment and implementation. It effectively synthesizes various disciplines to tackle clinically relevant problems. While the focus topic articles all share a biomedical engineering theme, they also represent exemplary samples of research in the fields of computational biology, cardiology, immunology, pharmacology and drug delivery, and neurology. As such, biomedical engineering represents a fine example of a node of convergence on the interconnected network of biological and scientific research.