2006-2330: FROM ELECTRICAL ENGINEERING TO BIOENGINEERING, WHAT IS THE SHORTEST PATH? WHAT IS THE BEST PATH?

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From Electrical Engineering to Bioengineering
What is the shortest path?
What is the best path?

Introduction or Abstract

In this paper we review a current issue in engineering education. How to address bio-engineering in engineering curricula? These days many engineering programs claim the word bio-engineering in their titles. This paper examines the requirements to include bioengineering, when bio referees to human health and medical issues. The paper identifies what an (electrical) engineer should know about "bio" to be able to solve problems in medical field. Finally, we address the questions than is facing many engineers, what is the best preparation for engineering students who would like to pursue an MD.

The need for addition of Biological Sciences to Electrical engineering

One of the hottest issues in (Electrical) engineering programs is the role of biology in engineering curriculum.[1-4] Every year more than 10% of the graduates of Electrical and Computer Engineering end up in medical related areas such as medical instrumentation design, and this number is increasing. In addition some graduates choose to pursue medical degrees.

From a scientific perspective, addition of biological sciences to engineering is inevitable because of exponential and synergistic collaboration among mathematical sciences such as engineering, and biological sciences (such as genetics, plant, and medical sciences), and to some degree social sciences. Furthermore, by addition of biological studies, engineering programs may become more popular and attract more women and under representative groups.

How to add Biological Sciences to Electrical engineering?

Many engineering curriculum committees are now addressing the ABET requirements regarding biology and other biological sciences in the engineering programs[1-3]. The question arises as to how an engineer can bridge the gap between her/his knowledge of engineering and its applications to medicine? Should programs require biology instead of chemistry, or both? In this paper we address how we can help our engineering students to be best prepared for and/or pursue a career in bioengineering, biological, and medical sciences?"[4]

To answer this question, let us first overview the curriculum of bio-medical engineering education in engineering schools & medical education in medical schools.

The Engineering curriculum

The traditional approach in bio-medical engineering education has been to emphasize the basic natural sciences such as biology, chemistry and physics, before applying it to engineering knowledge. Such disciplines emphasis basics as well as intermediate and advance understanding of many of the basics sciences. Other engineering programs have tried to adopt the basic requirement together with special classes that focus on the applications in the biomedical aspects of the discipline. This has been proven very practical and has attracted more than a few students. This is a long process and usually include more than just a few addition to the programs of study.

We need to seek the most practical and essential approach to give the students a useful and general solutions. In order to know what to do with our students we need to provide the student with good understanding of the medical field. Taking biology; even to that advance level may not help the students see the challenges and requirements of the medical related fields and professions. So, let us view this from another angle.

The medical curriculum

In order to diagnose and treat diseases, physicians are trained to understand mechanisms of diseases, and to do so, they study mechanisms of normal functioning of human body. Thus, the traditional medical school curriculum is divided into three hierarchical (interdependent) components: 1- basic sciences (Anatomy: studies of structure, and Physiology: studies of function) 2- basic sciences applied to diseases & their treatment (pathophysiology: Studies of abnormal functions, microbiology, pharmacology: treatment principles), and 3- clinical sciences (different medical specialties dealing directly with patients)[4]. This is depicted in Figure 1.

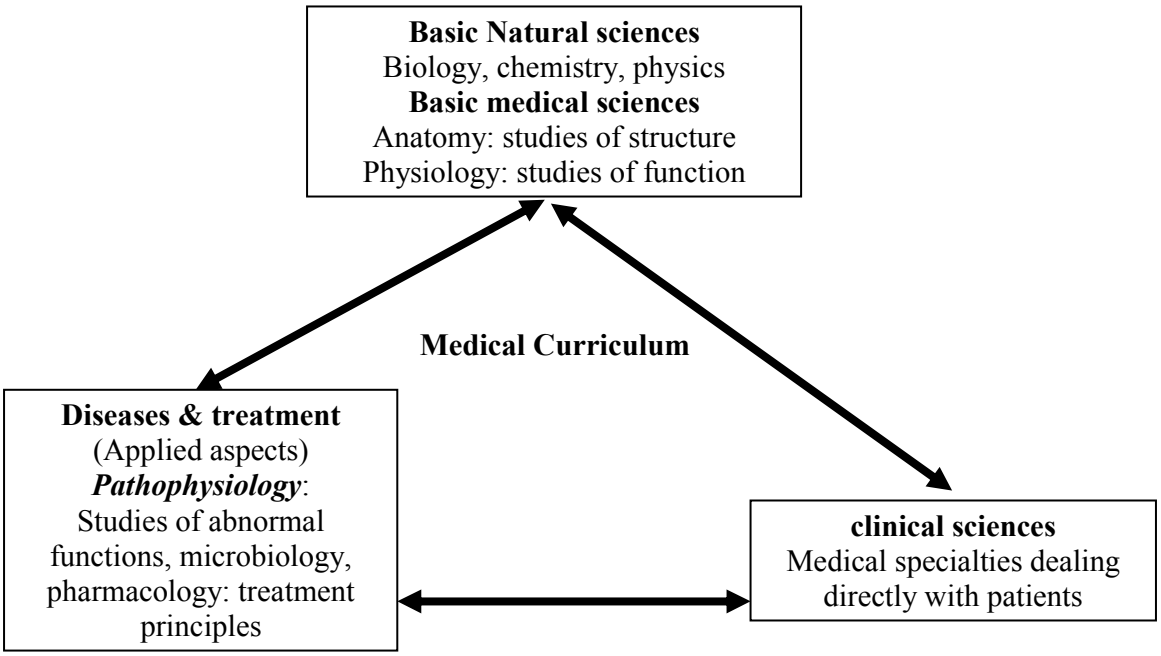

Figure 1. The typical medical Curriculum

It should be noted that basic sciences emphasized in bio-medical engineering education are not part of the medical curriculum (but are covered in pre-med studies). Instead medical education focuses on the application of these three basic sciences to studying human body functions, i.e. it focuses on studying physiology. Thus, it may be advantageous and indeed more direct and effective for bio-engineering programs to bridge the gap between engineering and medicine, not by repeating basic sciences such as biology, chemistry, or physics, but rather focusing on their application to study human body functions, i.e. focusing on human physiology.

It should be noted that to pursue careers in medical fields students need to know from the basics to the advanced level of the involved sciences. However, engineering students who would like to know what the field is about, and would like to know if they should pursue medical field applications (or become MDs) needs to know a more detailed understanding about the essence what is the medical fields and applications. Taking classes in biology and chemistry does not necessarily help with the answers to these questions. After all physiology is the science of the functions of organic creatures and discusses essential life processes, functions and activities. This is a branch of biology which deals with the functions and activities of living matter (such as organs, tissues, or cells) and of the physical and chemical phenomena involved. We believe this is the scientific essence of bio-medical fields, and encapsulates the needs, perspectives, and processes of thinking in medical related fields. Consequently, as a shortcut, what is meant to help student know the basics, understand the essence of the field, taking physiology would be a more constructive idea.

So what is the shortest path?

The complete answer to this question depends on what the student desires to do. In the case of those who would like to pursue a degree in medical field, they definitely need the basics as well as advance sciences.

If they would like to work in the field, appreciate the issues and understand the importance of medical related challenges, or be able to design for the field, we believe the most important and practical class to have is not biology or Chemistry, but *Physiology*. We propose this as the shortest (and maybe the best) approach for the engineering students. In addition, such a class will also familiarize the student with the subject of medicine and medical concepts more realistically. In case the student would like to pursue a degree in medical fields, this will be a great background as well as a wonderful gateway to the discipline.

Conclusion

Addition of biology and other related medical sciences to engineering seems to be one of the most important items in the engineering program curriculum. The main objective is to find the best way to achieve that. Should we allow biological classes to be accepted for the basic science requirements, should we have special biomedical classes added to the curriculums? The answer will vary.[4] While there is no "best" solution, in this paper we addressed the possibility of a shortcut. The authors believe the most efficient answer is to offer physiology classes that require very basic (high school) biology. These classes can be offered to provide the students with the

essence of medical field and medical related subjects. They also provide the students with the essence of what MD need to know, and gives them a realistic perspective of the issues, in case they would like to pursue studies in medicine.

For future research, the author propose that Engineering and Medical curricula officials actually sit together and formalize common classes (pathways) in their programs, which could lead to enhance collaboration and ease transition of students (and faculty) across programs and departments.

References

1. "Current trend of American medical education-the place of alternative medicine,"
Chakraborty, J.; Elkatib, M.; Purohit, A.; Kalla, S.; Engineering in Medicine and Biology Society, 1995 and 14th Conference of the Biomedical Engineering Society of India. An International Meeting, Proceedings of the First Regional Conference., IEEE15-18 Feb. 1995 Page(s):2/103 - 2/104. Digital Object Identifier 10.1109/RCEMBS.1995.532179
2. "Engineering education and research: TQM and R&D in bioengineering,"
Bruley, D.F.; Kang, K.A.; Moussy, F.; Wiesner, T.; Biomedical Engineering Conference, 1995., Proceedings of the 1995 Fourteenth Southern 7-9 April 1995 Page(s):130 – 133. Digital Object Identifier 10.1109/SBEC.1995.514458
3. "Turning students into science stars (science and engineering education)," Cocozza, J.D.; Brinton, R.D.; Engineering in Medicine and Biology Magazine, IEEE Volume 24, Issue 5, Sept.-Oct. 2005 Page(s):82 – 91. Digital Object Identifier 10.1109/MEMB.2005.1511504
4. "Clinical Engineers in he 21st Century," Baymond Peter Zambuto
IEEE Engineering in Medicine and Biology, may/June, 2004 pp37-41.