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# The Significant of Biomedical Engineering to Medical Field in Nigeria

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## Abstract
The biomedical engineering program is designed to integrate engineering and medical research spanning from the mechanics of man made materials investigations using engineering methods to explore fundamental physiological processes. Major emphasis of this program are in the areas of biomaterials, biomechanics, cardiovascular and biofluid mechanics, bioinstrumentation, the physical and mechanical behavior of tissues treated on engineering materials, the body response to implant materials, and bioengineering analysis of physiological control of the heart, respiration, temperature regulation, and the pupil. Coupled with these emphases in a strong interest in the development man evaluation of artificial organs and other implantable devices and finite element models. Another area of interest is biomedical systems, including systems physiology and the use of computers in health-care delivery.

## 1. Introduction

Preamble: the biomedical engineer as the nature is called involve in the engineering of medicine. Therefore the biomedical engineers occupies a special role, having a back ground in a branch of engineering, combined with a knowledge of the physical structure and function of the human body systems and an understanding of how there were engineering principles and methods can be applied to technical innovations and problem solving in the field of medicine.

Having this in mind, we can further say what is all about the discipline, “biomedical engineering science”. Biomedical engineering is a subject which covers all aspects of engineering applied to medicine, ranging from walking aids and wheelchairs to the complex instrumentation found in hospitals and research institutions.

Biomedical engineering (BME) can be defined as the application of engineering principles and techniques to the medical field. It combines the designed and problem solving skills of engineering with medical and biological sciences to improve health-care diagnosis and treatment.

Biomedical engineering has only recently emerged as its own discipline, compared to many other engineering fields, such as an evolution in common as new field transistions from being an interdisciplinary specialization among already established field to being considered a field in itself. During the last two decades its growth has paralleled that of the electronic and computer industries. Its contributions to improved medical treatment have resulted in a better quality of life and greater life expectancy in both the developed and the developing countries[1].

The numbers of elderly and physically disable in our communities are consequently growing at a rapid rate and this is placing an ever increasing demand on society to

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provide engineering technical solutions to help overcome their physical limitations.

Recognizing the important changing emphasis in society's needs, the Nigerians Universities/research institutes should mount and run program in biomedical engineering science which specializes in the application of engineering to rehabilitation of the physically disabled rehabilitation engineering.

Much of the work in biomedical engineering consists of research and development, spanning a broad array of subfields (see below). Problem biomedical engineering application include the development of biocompatible, prostheses, various diagnostic and therapeutic medical devices ranging from clinical equipment to micro-implants, common imaging equipment such as MRIs and EGGs, biotechnologies such as regenerative tissues growth and pharmaceutical drugs and biopharmaceuticals.

If this course is mounted, there should be close working relationships between the department of biomedical engineering and the departments of orthopedic surgery, internal medicine, dentistry and anesthesia and between biomedical engineering and other engineering disciplines including electrical and computer engineering, chemical, civil/environmental and mechanical engineering.

*Sub Disciplines Within Biomedical Engineering*

Biomedical engineering is a highly interdisciplinary field, influenced by (and overlapping with) various other engineering and medical fields. This often happens with newer disciplines, as they gradually emerge in their own right after evolving from special applications of extant disciplines. Due to this diversity, it is typical for a biomedical engineer to focus on a particular subfield or group of related subfields. There are many different taxonomic breakdowns within BME, as well as varying views about how best to organize them and manage any internal overlap; the main U.S. organization devoted to BME divides the major specialty areas as follows:

- Bioinstrumentation
- Biomaterials
- Cellular, tissue, genetic engineering
- Medical imaging
- Orthopedic bioengineering
- Rehabilitation engineering
- System physiology

Sometimes, disciplines within BME are classified by their association(s) with other, more established engineering fields, which can include:

*Chemical Engineering* - often associated with biochemical, cellular, molecular and tissue engineering, biomaterials, and biotransport.

*Electrical Engineering* - often associated with bioelectrical and neural engineering, bioinstrumentation, biomedical imaging, and medical devices. This also tends to encompass Optics and Optical engineering - biomedical optics, imaging and related medical devices.

*Mechanical Engineering* - often associated with biomechanics, biotransport, medical devices, and modeling of biological systems.

*Tissue Engineering* - Tissue Engineering is a major segment of Biotechnology.

One of the goals of tissue engineering is to create artificial organs (via biological material) for patients that need organ transplants. Biomedical engineers are currently researching methods of creating such organs. In one case bladders have been grown in lab and transplanted successfully into patients. Bioartificial organs, which utilize both synthetic and biological components, are also a focus area in research, such as with hepatic assist devices that utilize liver cells within an artificial bioreactor construct.

*Genetic Engineering* - Genetic engineering, recombinant DNA technology, genetic modification/manipulation (GM) and gene splicing are terms that apply to the direct manipulation of an organism's genes. Genetic engineering is different from traditional breeding, where the organism's genes are manipulated indirectly. Genetic engineering uses the techniques of molecular cloning and transformation to alter the structure and characteristics of genes directly. Genetic engineering techniques have found some successes in numerous applications. Some examples are in improving crop technology, the manufacture of synthetic human insulin through the use of modified bacteria, the manufacture of erythropoietin in hamster ovary cells, and the production of new types of experimental mice such as the oncomouse (cancer mouse) for research.

*Pharmaceutical Engineering* - Pharmaceutical Engineering is sometimes regarded as a branch of biomedical engineering, and sometimes a branch of chemical engineering; in practice, it is very much a hybrid sub-discipline (as many BME fields are). Aside from those pharmaceutical products directly incorporating biological agents or materials, even developing chemical drugs is considered to require substantial BME knowledge due to the physiological interactions inherent to such products' usage.

*Medical Devices* - This is an extremely broad category essentially covering all healthcare products that do not achieve their intended results through predominantly chemical (e.g., pharmaceuticals) or biological (e.g., vaccines) means, and do not involve metabolism.

A medical device is intended for use in:

- the diagnosis of disease or other conditions, or
- in the cure, mitigation, treatment, or prevention of disease,

Some examples include pacemakers, infusion pumps, the heart-lung machine, dialysis machines, artificial organs, implants, artificial limbs, corrective lenses, cochlear implants, ocular prosthetics, facial prosthetics, somatoprosthetics, and dental implants.

Stereo lithography is a practical example of medical modeling being used to create physical objects. Beyond modeling organs and the human body, emerging engineering techniques are also currently used in the research and development of new devices for innovative therapies, treatments, patient monitoring, and early diagnosis of complex diseases. Below figure ~~1,~~ is a schematic biomedical instrumentation amplifier used in monitoring low voltage biological signals, an example of a biomedical engineering application of electronic engineering to electrophysiology.

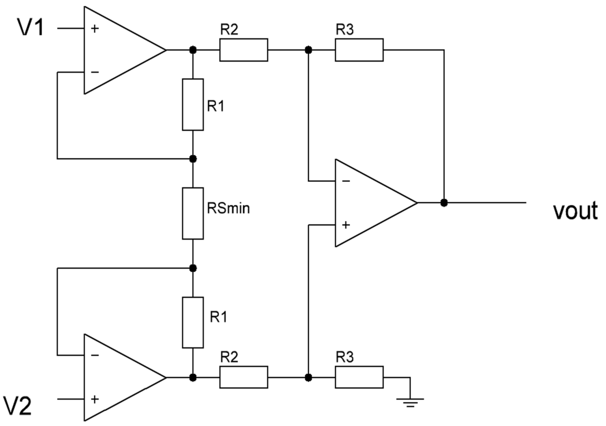


***Figure.*** *Instrumentation Amplifier.*

The required voltage signal for medical device can be obtain from the above amplification as express below.

$$V_1 = R_2 \, eqv \, (I_1 + I_2) \quad (1)$$

$$V_0 = I_1 R_{Smin} \quad (2)$$

$$V_{OUT} = I_1R_3 + V_1 - V_0 \quad (3)$$

$$\therefore V_{OUT} = I_1R_2 + R_2 \, eqv(I_1 + I_2) - I_1R_{Smin} \quad (4)$$

$$V_{OUT} = I_1R_3 + \frac{R_1R_2}{R_1+R_2}[I_1 + I_2] - I_1\left[\frac{R_{eqv}R_x}{R_{eqv}R_x}\right] \quad (5)$$

Many particular electrophysiological readings have specific names:

- Electrocardiography – for the heart
- Electroencephalography – for the brain
- Electromyography – for the muscles
- Electroculography – for the eyes
- Electroretinography – for the retina
- Electroantennography – for olfactory receptor receptors in arthropods.

## 2. Medical Imaging

Medical/Biomedical Imaging is a major segment of Medical Devices. This area deals with enabling clinicians to directly or indirectly "view" things not visible in plain sight (such as due to their size, and/or location). This can involve utilizing ultrasound, magnetism, UV, other radiology, and other means.

- Imaging technologies are often essential to medical diagnosis, and are typically the most complex equipment found in a hospital including:
- Fluoroscopy
- Magnetic resonance imaging (MRI)
- Nuclear Medicine
- Positron Emission Tomography (PET) PET scans PET-CT scans
- Projection Radiography such as X-rays and CT scans
- Tomography
- Ultrasound
- Electron Microscopy

## 3. Implants

An implant is a kind of medical device made to replace and act as a missing biological structure (as compared with a transplant, which indicates transplanted biomedical tissue). The surface of implants that contact the body might be made of a biomedical material such as titanium, silicone or apatite depending on what is the most functional. In some cases implants contain electronics e.g. artificial pacemaker and cochlear implants. Some implants are bioactive, such as subcutaneous drug delivery devices in the form of implantable pills or drug-eluting stents.

## 4. Clinical Engineering

Clinical engineering is the branch of biomedical engineering dealing with the actual implementation of medical equipment and technologies in hospitals or other clinical settings. Major roles of clinical engineers include training and supervising biomedical equipment technicians (BMETs), selecting technological products/services and logistically managing their implementation, working with governmental regulators on inspections/audits, and serving as technological consultants for other hospital staff (e.g. physicians, administrators, I.T., etc). Clinical engineers also advise and collaborate with medical device producers regarding prospective design improvements based on clinical experiences, as well as monitor the progression of the state-of-the-art so as to redirect procurement patterns accordingly.

In their various roles, they form a “bridge” between the primary designers and the end- users, by combining the perspective of being both one.

### Training and Certification

Biomedical Engineering is still yet to be embrace by the universities in Nigeria. It is just recently that some of the universities has introduced biomedical engineering but at every lower level. Seeing the important and the major roles play in the medical, pharmaceutical industry, hospitals, it is encourage able to introduce this program or course in our university which has the man-power.

## 5. Education

Biomedical engineers require considerable knowledge of both engineering and biology, and typically have a Masters (M.S., M.S.E., or M. Eng.) or a Doctoral (Ph.D.) degree in BME or another branch of engineering with considerable potential for BME overlap. As interest in BME is increasing, many engineering colleges or faculties now do have a Biomedical Engineering Department or Program, which offers a program ranging from the undergraduate (B.S. or B.S.E.) to the doctoral levels. As noted above, biomedical engineering has only recently been emerging as its own discipline rather than a cross-disciplinary hybrid specialization of other disciplines; now, BME programs of study at all levels are becoming more widespread, including the Bachelor of Science in Biomedical Engineering which actually includes so much biological science content that many students use it as a "pre-med" major in preparation for medical school. The number of biomedical engineers is expected to rise as both a cause and effect of improvements in medical technology.

In the U.S., an increasing number of undergraduate programs are also becoming recognized by ABET as accredited bioengineering/biomedical engineering programs. Over 40 programs are currently accredited by ABET.

As with many degrees, the reputation and ranking of a program may factor into the desirability of a degree holder for either employment or graduate admission. The reputation of many undergraduate degrees are also linked to the institution's graduate or research programs, which have some tangible factors for rating, such as research funding and volume, publications and citations. With BME specifically, the ranking of a university's hospital and medical school can also be a significant factor in the perceived prestige of its BME department/program.

Graduate education is a particularly important aspect in BME. While many engineering fields (such as mechanical or electrical engineering) do not need graduate-level training to obtain an entry-level job in their field, most BME positions do prefer or even require them. Since most BME-related professions involve scientific research, such as in pharmaceutical and medical device development, graduate education is highly desirable (as undergraduate degrees typically do not involve sufficient research training and experience). This can be either a Masters or Doctoral level degree; while in certain specialties a Ph.D. is notably more common than in others, it is hardly ever the majority (except in academia). In fact, the perceived need for some kind of graduate credential is so strong that some undergraduate BME programs will actively discourage students from majoring in BME without an expressed intention to also obtain a masters degree or apply to medical school afterwards.

Graduate programs in BME, like in other scientific fields, are highly varied, and particular programs may emphasize certain aspects within the field. They may also feature extensive collaborative efforts with programs in other fields (such as the University's Medical School or other engineering divisions), owing again to the interdisciplinary nature of BME. M.S. and Ph.D. programs will typically require applicants to have an undergraduate degree in BME, or another engineering discipline (plus certain life science coursework), or life science (plus certain engineering coursework).

Education in BME also varies greatly around the world. By virtue of its extensive biotechnology sector, its numerous major universities, and relatively few internal barriers, the U.S. has progressed a great deal in its development of BME education and training opportunities. Europe, which also has a large biotechnology sector and an impressive education system, has encountered trouble in creating uniform standards as the European and Brazilcommunity attempts to supplant some of the national jurisdictional barriers that still exist. Recently, initiatives such as BIOMEDEA have sprung up to develop BME-related education and professional standards.[6] [7] [8] Other countries, such as Australia, are recognizing and moving to correct deficiencies in their BME education. Also, as high technology endeavors are usually marks of developed nations, [9]some areas of the world are prone to slower development in education, including in BME.

## 6. The Ten Most Important Biomedical Engineering Devices

The most important biomedical engineering devices are those that save the most lives and/or improve the lives of the most people [10].

(1) The X-ray machine images internal organs and thus discovers internal abnormalities and tumors in time to remove them;

(2) Computed tomography generates slice images of internal organs with improved contrast and spatial resolution;

(3) Magnetic resonance imaging generates slice images of soft tissue and internal organs without radiation exposure;

(4) The heart-lung machine oxygenates and pumps the blood to permit operations on the open heart to correct abnormalities and to replace diseased valves;

(5) The artificial kidney extracts urea from the blood to extend the lives of those with end-stage kidney disease so that some have time to receive a kidney transplant;

(6) The electrosurgical unit makes tissue cutting easier to shorten surgical time and cauterizes tissue to prevent blood loss;

(7) The cardiac pacemaker stimulates the dysfunctional heart and restores proper rhythm to many who otherwise would be invalids or die;

(8) The pulse oximeter noninvasively measures tissue oxygen saturation of anesthetized patients to ensure proper oxygenation and perfusion;

(9) The ventilator permits operations on anesthetized patients and breathes for patients who have pulmonary crises; and

(10) Artificial hips, knees and other joints restore movement to those with mobility problems.

## 7. Conclusion

The numbers of elderly and physical disabled in our communities are consequently growing at a rapid rate and this is placing an ever increasing demand on society to provide engineering and technical solution to help overcome their physical limitations.

Recognizing this important changing emphasis in society's needs, the school, faculty or college of engineering in collaborations with other department in medicine to mount and run BME as to offer a B. Eng, M. Eng to Ph. D level course in biomedical engineering science, which will specializes in the application of engineering to rehabilitation of the physically disabled – rehabilitation engineering.

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