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A Healthy Transformation to Mankind: Biomedical Engineering

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Abstract:- Biology is a natural science concerned with the study of life and living organisms. It is important to everyday life because it allows people to better understand their bodies, resources and potential threats in the environment including the diversity of life forms, their conservation and exploitation. As an application of natural sciences especially to biology and physiology, Biomedical plays a vital role to clinical medicine. Biomedical sciences are devoted towards the development of knowledge, interventions, or technology for healthcare or public health using a set of applied sciences whether natural or formal, or both. It is the branch of medicine that deals with the application of the biological sciences, especially biochemistry, molecular biology, and genetics, to the understanding, treatment, and prevention of disease. One step furthers to this Biomedical Engineering (BME) seeks to close the gap between engineering and medicine, combining the design and problem solving skills of engineering with medical and biological sciences to advance health care treatment, including diagnosis, monitoring, and therapy. Some of the prominent biomedical engineering applications 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 EEGs, regenerative tissue growth, pharmaceutical drugs and therapeutic biological.

The objective of this paper is to provide elaborate knowledge of different aspects of BME and also underline its working importance in healthcare. This paper elaborately presents some of the prominent introductory definitions of BME followed by its evolution and discusses various contributors to BME. It also describes different fields of BME along with its working phases used with various medical modalities like CT, MRI etc. Next section of the paper presents the working principle of BME using a medical image diagnosis example of Human Body. Specialist areas of discipline and some of its uses are given. Furthermore Research prospective of BME is shown followed by its benefits to mankind such as Organ transplantation and tissue engineering. The paper concluded by unveiling some of the further offerings of the field in the Bio healthcare system to make it more fruitful and better both for patients and doctors.

Keywords:- Biology, Biomedical, Biomedical Engineering, Diagnosis.

I. INTRODUCTION

'Bio' denotes all things which are connected with life. Man has learnt the use of herbs for treatment and the knowledge of botany becomes essential for the practitioner of medicine [1].Biomedical is the application of natural sciences like biological and physiological to clinical medicine, concerned with the effects of environment on human body.

According to G.S.Sawhney in his book Fundamental of Biomedical Engineering "Prefix "bio" denotes something connected with life. When basic sciences of physics and chemistry have been applied to living things, this intermarriage has been named as biophysics and biochemistry. Hence, marriage of discipline of medicine and engineering is called biomedical engineering. The aim of biomedical engineering is the application of the methodology and technology of physical sciences and engineering to the problem of the living systems with emphasis on diagnosis, treatment and prevention of diseases in man."[1]

As the above definition states and over the last few years there has been a major paradigm shift from traditional schemes of health care towards health care systems which are much more dependent on technology. This is true in terms of diagnosis (e.g. body scanners); treatment (radiation therapy and minimal access surgery); and health care system integration (via information technology). we are now living in the period of Diagnosis and Visualization where combining the application of the principles and problem-solving techniques of two extreme disciplines biomedical and engineering is the need of hour in order to answer many unsolved scientific questions to the fields of biology and health care. It has also given us answer to question Doctors or Engineers? **Why not to be both i.e. Biomedical Engineers.**

Engineering itself is an innovative field, the origin of ideas leading to everything from techniques to technology whatever we are having. Biomedical engineering focuses on the advances that improve human health and health care at all levels. Bioengineers work with Physicians, therapists and researchers to develop systems, equipment and devices in order to solve clinical problems. It is not identical to many of the engineering disciplines, it focuses on the use and application which deploys knowledge of modern biological principles with engineering design processes.

II. EVOLUTION OF BIOMEDICAL ENGINEERING

Discovered by a team at the Wyss Institute and the Harvard School of Engineering and Applied Sciences, the finding was published on January 25 in the journal Proceedings of the National Academy of Sciences, quotes [2]:"The results of their new study demonstrate how direct physical and mechanical intervention can impact biological processes and can potentially be exploited to improve clinical outcomes".

Biomedical engineering has evolved over the decades, 3,000-year-old Egyptian mummy`s wood and leather prosthetic toe is considered the first engineered piece of work used by any patient. Simple bandage crunches and walking sticks were also considered as a form of engineered assistance machines. With the development in the science and technology, proliferation in biomedical engineering takes place slowly but steadily by developing techniques and implementing them through devices to diagnose, rehabilitate the injuries in much more effective ways helping physician as well as patient.

Some of the notable developments during the evolution process of biomedical engineering along with their inventors are mentioned in the Table 1[3]:

Table I: Notable Developments Along with Their Inventors in Biomedical Engineering Evolution

Contributors to Biomedical Engineering	
Forrest Bird	Mechanical ventilator
John Charnley	Artificial hip replacement
Graeme Clarke	Cochlear implant
Willem Einthoven	Electrocardiograph
Wilson Greatbatch	Internal cardiac pacemaker
Charles Hufnagel	Artificial heart valve
Robert Jarvik	Artificial heart
Willem Johan Kolff	Kidney dialysis
Rene Laennec	Stethoscope
Michel Mirowski	Implantable cardioverter defibrillator
Wilhelm Roentgen	X-rays

III. FIELDS IN BIOMEDICAL ENGINEERING

Different aspects and disciplines of Engineering, Computer Science, Chemistry, Mathematics, Material Science along with Human Biology are clubbed together to work well in biomedical as engineering to uplift the health care system as shown in Fig. 1 [4].

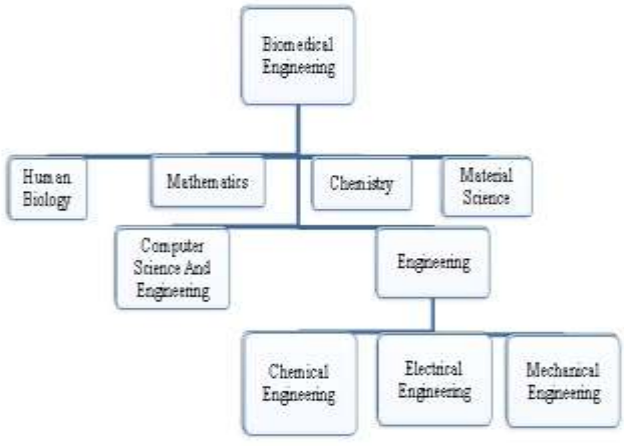

Fig. 1: Fig 1: Field in Biomedical Engineering

Human Biology *:* It is an interdisciplinary area of study that examines humans through the influences and comprises of many diverse fields such as genetics, evolution, physiology, anatomy, epidemiology, anthropology, ecology, nutrition, population genetics and sociocultural influences.

Chemistry*:* It is valuable in bioengineering, include polymer chemistry (materials science) and surface chemistry.

Mathematics*:* It is foundational component of engineering. When it comes to analyzing and designing medical solutions, calculus and geometry skills are needed. In designing an artificial heart, for instance, the engineer must use advanced math to consider the fit of the organ in the body.

Materials Science*:* It is the study of the relationships between the synthesis, processing, structure, properties, and performance of materials that enable an engineering function. The properties of interest can be mechanical, electrical, magnetic or optical; the engineering functions involved are electronics, communications, medicine, transportation, manufacturing, recreation, energy, and the environment.

Chemical Engineering*:* It is associated with biochemical, cellular, molecular and tissue engineering, biomaterials and biotransport.

Electrical Engineering*:* It is 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: It is associated with biomechanics, biotransport, medical devices, and modeling of biological systems, like soft tissue mechanics.

IV. BIOMEDICAL ENGINEERING WORKING PHASES

There are many phases within biomedical engineering that has to be followed such as the design and development of active and passive medical devices for rehabilitation, orthopedic implants, medical imaging for better diagnose, biomedical signal processing, tissue and stem cell engineering, and clinical engineering. Fig. 2 demonstrates the different phases of Biomedical engineering discussed here [4].

1) Active and passive medical devices for rehabilitation: Medical devices are classified on the basis of the level of risk for the user, the location and method of use, dependence on the power source, useful life and other characteristics. With regard to their dependence on the power source medical devices are classified into active and passive medical devices like heart pacemaker (active) and knee implant (passive).

2) Orthopedic implants: An orthopedic implant is a medical device manufactured to replace a missing joint or bone or to support a damaged bone. The medical implant is mainly fabricated using stainless steel and titanium alloys for strength and the plastic coating that is done on it acts as an artificial cartilage.

3) Medical imaging for better diagnose: Diagnostic imaging techniques help narrow the causes of an injury or illness and ensure that the diagnosis is accurate. These techniques include X-rays, Computed Tomography (CT) Scans, Magnetic Resonance Imaging (MRI).

4) Biomedical signal processing: Biomedical signal processing involves the analysis of measurements of these techniques to provide useful information upon which physician can make decisions.

5) Tissue and stem cell engineering: Tissue engineering, as viewed today, is ‘an interdisciplinary field that applies the principles of engineering and life sciences toward the development of biological substitutes that restore, maintain, or improve tissue function or a whole organ.’[10]

6) Clinical engineering: Applies medical technology to optimize healthcare delivery.

Fig. 2: Working Phase of Biomedical Engineering

V. WORKING PRINCIPLE

Access to adequate health care is comparable to the fundamental rights of a human being. The view has led to the development of large and sophisticated health care systems. The components of health care system in BME followed by the physician to provide treatment are as follows:

1) Diagnosis: The most important and critical element is diagnosis as the further treatment depends upon right diagnosis only. Once it appears to be in right direction a physician makes a roadmap accordingly. Now a day’s Image Diagnosis become one of the mandatory part of medical treatment system the use of CT-Scan, MRI, OCT, SPECT are common as it help the physician to decide the further steps of treatment. Computerized quantification helps in the diagnostic evaluation of variety of images found and as it owe a variety of visualization tools which provide extensible image processing capabilities such as N-dimensionality in the visualization program me, platform independent nature make them a mandatory factor used by the physicians is quite efficient and effective as shown in Fig. 3.

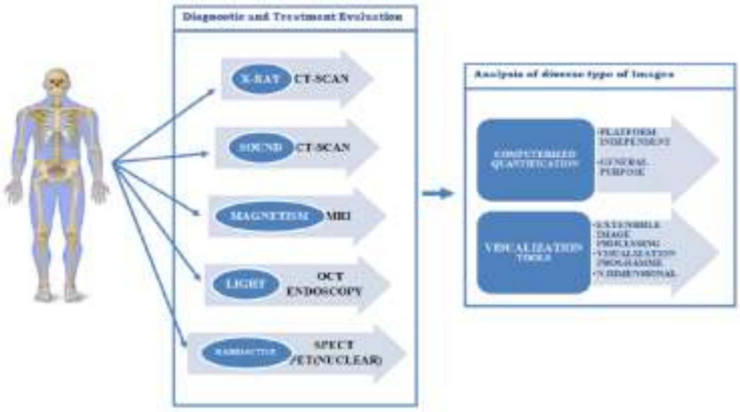

Fig 3: Medical Image Diagnosis of Body in Bio Medical Engineering

2) Treatment: Physician then prescribes the treatment according to the results of the diagnosis, and then monitor it and to assess its adequacy to maintain or modify the treatment based on the progress of patient.

3) Rehabilitation: Thus this process of helping a patient who has suffered an illness or injury restore lost health and so regain maximum self-sufficiency is to rehabilitate them by applying the selected therapy according to their diagnosis.

For the above cycle to follow it become necessarily vital to have high technology medical equipments in health care industry as this industry is growing at fast rate, and it normally require more skills, to control the correct functionality of these equipments, one has to understand its basic operating principles and be able to apply some performance assurance tests for that purpose. The physicians then utilizing the results produced with these equipments must understand the limitations of the technology, and this produces a gap addressing the issue that is physicians and biomedical engineers cannot work in isolation.

Biomedical engineer is a professional who has expertise both in biological sciences and engineering field so as to effectively and safely manage medical devices and instruments, for an overall enhancement of health care. He can use engineering expertise to analyse and solve problems in biology and medicine providing an overall improvement of health care. Biomedical engineers typically do the following [5]:

- Design equipment and devices, such as artificial internal organs, replacements for body parts, and machines for diagnosing medical problems.
- Install, adjust, maintain, repair, or provide technical support for biomedical equipment.
- Evaluate the safety, efficiency, and effectiveness of biomedical equipment.
- Train clinicians and other personnel on the proper use of equipment.
- Work with life scientists, chemists, and medical scientists to research the engineering aspects of the biological systems of humans and animals.
- Prepare procedures, write technical reports, publish research papers, and make recommendations based on their research findings.
- Present research findings to scientists, nonscientist executives, clinicians, hospital management, engineers, other colleagues, and the public.

VI. SPECIALIST AREA OF DISCIPLINES IN BIOMEDICAL ENGINEERING

Biomedical engineering is a highly interdisciplinary field, influenced by (and overlapping with) various other engineering and medical fields. Due to this diversity, it is typical for a biomedical engineer to focus on a particular subfield or group of related subfields. For the effective utilization of high technology equipments, system necessitates the technical expertise therefore depending upon personnel working in different areas of biomedical engineering, the following Specialist areas are shown in Table 2[6]:

Table 2: SPECIALIST AREA OF DISCIPLINES IN BIOMEDICAL ENGINEERING

Bio-materials	It is any matter, surface, or construct that interacts with biological systems
Bio-mechatronics	It is an applied interdisciplinary science that aims to integrate mechanical elements, electronics and parts of biological organisms
Bio-mechanics	It is the branch of biophysics that deals with the mechanics of the human or animal body; especially concerned with muscles and the skeleton or the functioning of a particular part of a body
Bionic	It is also known as biomimicry, biomimetics, bio-inspiration,

	biognosis, and close to bionical creativity engineering) is the application of biological methods and systems found in nature to the study and design of engineering systems and modern technology
Clinical engineering	It is a specialty within Biomedical engineering responsible primarily for applying and implementing medical technology to optimize healthcare delivery
Bio-instrumentation	It is the application of electronics and measurement principles and techniques to develop devices used in diagnosis and treatment of disease
Bio-nanotechnology	It is usually refers to intersect between biotechnology and nanotechnology
Medical imaging	It is the technique and process used to create images of the human body (or parts and function thereof) for clinical purposes (medical procedures seeking to reveal, diagnose or examine disease) or medical science (including the study of normal anatomy and physiology
Cellular engineering	It is a new field that addresses issues related to understanding and manipulating cell structure-function relationships
Tissue engineering	It is a sub-field of bio materials, It is the use of a combination of cells, engineering and materials methods, and suitable biochemical and physio-chemical factors to improve or replace biological functions
Genetic engineering or genetic modification	It is the direct human manipulation of an organism's genetic material in a way that does not occur under natural conditions. It involves the use of recombinant DNA techniques, but does not include traditional animal and plant breeding or mutagenesis
Neural engineering	It is a discipline within biomedical engineering that uses engineering techniques to understand, repair, replace, enhance, or otherwise exploit the properties of neural systems. Neural engineers are uniquely qualified to solve design problems at the interface of living neural tissue non-living constructs
Pharmaceutical engineering	It is a branch of Pharmaceutical Technology that involves development, commercialisation and manufacturing components within the pharmaceuticals industry
System physiology	It is the science of the mechanical, physical, bioelectrical, and biochemical functions of humans in good health, their organs, and the cells of which they are composed. Physiology focuses principally at the level of organs and systems
Rehabilitation engineering	It is the systematic application of engineering sciences to design, develop, adapt, test, evaluate, apply, and distribute technological solutions to problems confronted by individuals with disabilities
Orthopaedic bioengineering	It builds upon strong programs in biomechanics and biomaterials. The field embraces the study of joint function, prosthetic replacement, and a broad range of orthopaedic related research such as electrical stimulation effects on fracture repair, injury, repair, and regeneration of tendons and ligaments, and biomechanicial effects on bone cells.

VII. RESEARCH IN BIOMEDICAL ENGINEERING

Biomedical engineering work is basically of research and development it is a discipline that advances knowledge in Engineering, Biology and Medicine, and improves human health through cross-disciplinary activities that integrate the Engineering Sciences with the biomedical sciences and clinical practice. The term "biomedical engineering research" is thus defined in a broad sense: It includes not only the relevant applications of engineering to medicine but also to the basic life sciences. It includes:

- The acquisition of new knowledge and understanding of living systems through the innovative and substantive application of experimental and analytical techniques based on the engineering sciences.
- The development of new devices, algorithms, processes and systems that advance biology and medicine and improve medical practice and health care delivery.[7]
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VIII. BENEFITS TO MANKIND

Biomedical engineers have solved the problem for the patients that need organ transplants. Now they are researching on tissue engineering to create artificial organs. They have grown tracheas and jawbones from human stem cells. They have successfully grown artificial urinary bladders in laboratories and transplanted into human patients.

IX. CONCLUSION

Whether it is implantable medical devices or diagnosis and analysis to treatment and recovery, Biomedical Engineering is publically acceptable as well as approachable and become an essential element of health care system now days to common patients. This paper discusses the concept of Biomedical Engineering which seems to be the most prominent field in the coming decades as data sciences and software. Different fields which are clubbed together in biomedical engineering so that doctors will do much better and much more cheaply by machine and machine learning algorithm. Due to the specialist area the futuristic techniques like stem cell engineering and the 3-D printing of biological organs are a big success and are evident throughout Bio healthcare domain.

REFERENCES

[1]. G.S.Sawhney, Fundamental of Biomedical Engineering, New Age International Publication, New Delhi.
[2]. Wyss Institute and the Harvard School of Engineering and Applied Sciences, January 25, 2016, Proceedings of the National Academy of Sciences.
[3]. http://www.livescience.com/48001-biomedical-engineering.html
[4]. https://en.wikipedia.org/wiki/Human_biology
[5]. https://collegegrad.com/careers/biomedical- engineers.
[6]. http://www.biotecharticles.com/Biology-Article/Biomedical-Engineering-Its-Introduction-and-Sub disciplinary-Fields-675.html
[7]. http://www3.imperial.ac.uk/pls/portallive/docs/1/51182.PDF
[8]. http://wyss.harvard.edu/viewpressrelease/240/newfound-strength-in-regenerative-medicine
[9]. http://www.mtu.edu/biomedical/department
[10]. Langer R, Vacanti JP. Tissue engineering. Science. 1993; 260:920–926. [PubMed]