Recent Trends in Biomedical Engineering: A Mini Review

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Abstract—*Biomedical Engineering (BME) is one of the hottest and fastest growing field in engineering at present. It is sometimes painted as an emerging field or that has come to the fore very recently. Biomedical Engineering is a highly interdisciplinary and well established discipline spanning across Engineering, Medicine and Biology. It covers recent advances in the growing field of biomedical technology, instrumentation, and administration. Contributions focus on theoretical and practical problems associated with the development of medical technology, the introduction of new engineering methods into public health, hospitals and patient care, the improvement of diagnosis and therapy, biomedical information storage and retrieval. The latest trends in biomedical engineering are mostly around diagnostic tools and modalities which greatly help healthcare providers today in diagnosing and recognizing early signs of fatal yet preventable diseases. These biomedical technologies also help countless patients by improving the quality of their health. In this review, we will discuss the newest trends in biomedical engineering include: enhanced bone regeneration; tissue bioengineering; biosensors; bioinstrumentation and drug delivery.*

Keywords*: Biomedical Engineering, Bone Regeneration, Tissue Bioengineering, Biosensors, Bioinstrumentation, Drug delivery.*

1. INTRODUCTION

Biomedical engineering 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 clincal practice [1]. It includes 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. It involves the development of new devices, algorithms, processes and systems that advance biology and medicine and improve medical practice and health care delivery [2]. 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 [3]. 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 include preventive medicine, diagnosis, therapy and rehabilitation. The critical element in this chain is diagnosis [4]. The latest trends in biomedical engineering are mostly around diagnostic tools and modalities which greatly help healthcare providers today in diagnosing and recognizing early signs of fatal yet preventable diseases. These biomedical technologies also help countless patients by improving the quality of their health [5-6]. In this review, we will discuss the newest trends in biomedical engineering include: enhanced bone regeneration; tissue bioengineering; biosensors, bioinstrumentation and drug delivery.

2. BONE REGENERATION

The worldwide incidence of bone disorders and conditions has trended steeply upward and is expected to double by 2020, especially in populations where aging is coupled with increased obesity and poor physical activity [7]. Engineered bone tissue has been viewed as a potential alternative to the conventional use of bone grafts, due to their limitless supply and no disease transmission. However, bone tissue engineering practices have not proceeded to clinical practice due to several limitations or challenges [8]. Bone tissue engineering aims to induce new functional bone regeneration via the synergistic combination of biomaterials, cells, and factor therapy. The fundamentals of bone tissue engineering highlight the current state of this field. Further, the recent advances of biomaterial and cell-based research, as well as approaches used to enhance bone regeneration [9]. Specifically, biomaterial scaffolds, hydrogels (Fig.1) their micro and nanostructural properties, and incorporation of biomimetic properties and/or growth factors are widely investigated for biomedical applications. In addition, various cellular approaches, including the use of mesenchymal stem cells (MSCs), embryonic stem cells (ESCs), adult stem cells, induced pluripotent stem cells (iPSCs), and platelet-rich plasma (PRP), and their clinical application strengths and limitations [10]. By overviewing the challenges that face the bone tissue engineering field, such as the lack of sufficient vascularization at the defect site, the research aimed at functional bone tissue engineering. These challenges will drive future research in the field [11].

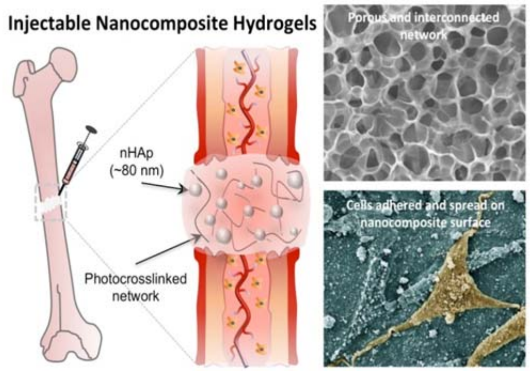

Fig. 1: Injectable nanocomposite hydrogel for bone regeneration

3. TISSUE BIOENGINEERING

Tissue engineering evolved from the field of biomaterials development and refers to the practice of combining scaffolds, cells, and biologically active molecules into functional tissues (Fig.2). The goal of tissue engineering is to assemble functional constructs that restore, maintain, or improve damaged tissues or whole organs [12]. Artificial skin and cartilage are examples of engineered tissues that have been approved by the FDA; however, currently they have limited use in human patients. Currently, tissue engineering plays a relatively small role in patient treatment. Supplemental bladders, small arteries, skin grafts, cartilage, and even a full trachea have been implanted in patients, but the procedures are still experimental and very costly [13]. While more complex organ tissues like heart, lung, and liver tissue have been successfully recreated in the lab, they are a long way from being fully reproducible and ready to implant into a patient [14]. These tissues, however, can be quite useful in research, especially in drug development. Using functioning human tissue to help screen medication candidates could speed up development, saving money and animals, and provide key tools for facilitating personalized medicine [15].

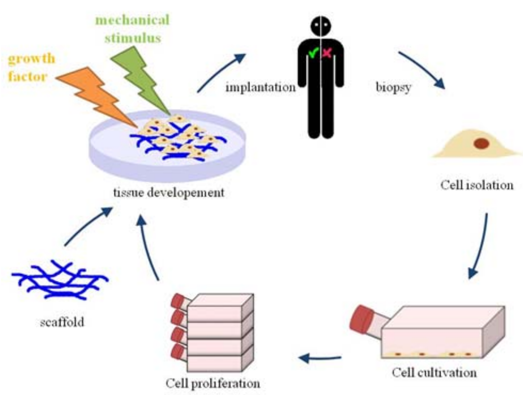

Fig. 2: Tissue Bioengineering

4. BIOSENSORS

On a global scale, high mortality rates of various infectious diseases and cancers are symptomatic of inadequate diagnostic tools because of high cost of, and poor access to, medical care [16]. The available assays at the moment may suffer from poor sensitivity, selectivity, as well as being time-consuming [17]. Therefore, a large demand exists for the development of an efficient device that provides sensitive and selective results for early detection of said diseases, thus improving prognosis as well as lowering the mortality rate [18]. Scientists have developed various medical biosensors which seek to address the aforementioned shortcomings. POC biosensors allow for the sensitive, selective, and rapid detection of diseases while remaining inexpensive [19]. Quantification and regulation of pathway metabolites is crucial for optimization of microbial production bioprocesses. Genetically encoded biosensors provide the means to couple metabolite sensing to several outputs invaluable for metabolic engineering. These include semi-quantification of metabolite concentrations to screen or select strains with desirable metabolite characteristics, and construction of dynamic metabolite-regulated pathways to enhance production [20]. Taking inspiration from naturally occurring systems, biosensor functions are based on highly diverse mechanisms including metabolite responsive transcription factors, two component systems, cellular stress responses, regulatory RNAs, and protein activities [21].

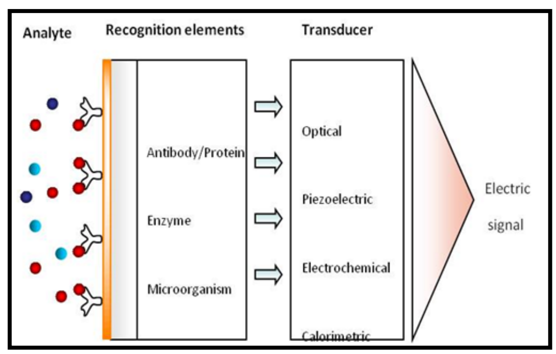

Fig. 3: Schematic diagram of biosensor

5. BIOINSTRUMENTATION

Biomedical Instrumentation Engineering involves developing new devices and procedures that solve medical and health-related problems by combining their recent advances knowledge in engineering, biology, and medicine to improve human health through cross-disciplinary activities that integrate the engineering sciences with the biomedical sciences and clinical practice [22]. Biomedical engineers may spend their days designing electrical circuits and computer software for medical instrumentation [23]. These instruments may range from large imaging systems such as conventional x-ray, computerized tomography and magnetic resonance imaging, to small implantable devices, such as pacemakers, cochlear implants, drug infusion pumps and some of the prominent biomedical applications include the development of various diagnostic and therapeutic medical devices ranging from common imaging equipment such as MRIs and EEGs, regenerative tissue growth, pharmaceutical drugs and therapeutic biologicals [24]. An evolutionary product is a new model of an existing product that adds new features, improves the technology, and reduces the cost of production [25].

6. DRUG DELIVERY

Clinicians historically have attempted to direct their interventions to areas of disease or areas at risk for disease. Depending on the medication, the way it is delivered, and how our bodies respond, side effects sometimes occur. These side effects can vary greatly from person to person in type and severity. For example, an oral drug for seasonal allergies may cause unwanted drowsiness or an upset stomach. Administering drugs locally rather than systemically (affecting the whole body) is a common way to decrease side effects and drug toxicity while maximizing a treatment's impact. A topical (used on the skin) antibacterial ointment for a localized infection or a cortisone injection of a painful joint can avoid some of the systemic side effects of these medications. There are other ways to achieve targeted drug delivery, but some medications can only be given systemically.

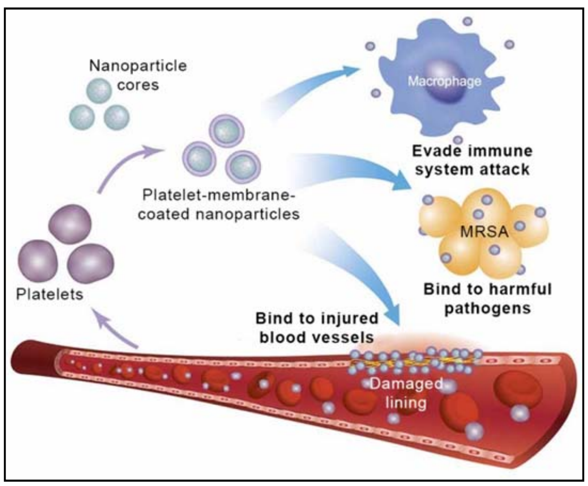

Fig. 4: Targeted drug delivery with nanoparticles.

7. CONCLUSION

Biomedical Engineering is application of knowledge of engineering, biology, and biomechanical principles to the design, development, and evaluation of biological and health systems and products, such as artificial organs, prostheses, instrumentation, medical information systems, and health management and care delivery systems

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