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Editorial

Design and Research of Biomaterials

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Trauma, degeneration, and illness frequently necessitate surgical intervention. This generally demands the alternative of skeletal parts such as vertebrae, knees, teeth, fingers joints, hips, elbows, and other bodily important organs such as kidneys, skin, the heart, and so on. All these substances, when replaced, serve the corresponding role of biological materials and are referred to as "biomaterials." The National Institutes of Health Consensus Development Conference (NIHCDC) defines biomaterials as "any substance (other than a drug) or combination of substances, of natural or synthetic origin, for any period of time that can be used, as a part or as a whole of a system that treats, augments, or replaces any tissue, organ, or function of the body" [1]. Biomaterials can be employed in many sections of the human body as stents in blood arteries, prosthetic valves in the heart, and replacement implants in the hips, shoulders, ears, knees, elbows, and orthodontic structures [2].

Biomaterials were used in our ancient cultures in the form of prosthetic ears, eyes, teeth, and noses, which have all been discovered on Egyptian mummies. Natural biomaterials such as wood, glue, rubber, and living tissues, as well as artificial materials such as iron, gold, silver, zinc, and glass, were employed as biomaterials at the outset. In Indian and Chinese cultures, biomaterials such as waxes, glues, and tissues were used to reconstruct or repair damaged body parts [1]. The bones of a human discovered in Kennewick, WA (called the "Kennewick Man"), revealed the use of a spear point implanted in his hip that was dated to 9000 years ago [3]. A corpse discovered in Europe around 200 AD with an iron dental implantation was found to be successfully bone integrated [4]. Bone plates were developed in the early 1900s to help in the fixing of longitudinal bone ruptures [5]. With the emergence of cobalt-chromium and stainless-steel alloys in the 1930s, fracture repair became more successful, and the first joint replacement procedures were undertaken [6]. Due to their exceptional characteristics, synthetic and natural polymers are popular alternatives in biomedical applications. Natural polymers, such as collagen and fibronectin, silk fibroin, fibrin, chitosan, and others, have good bioactivity and cytocompatibility, whereas synthetic polymers have remarkable physicochemical features, for example, mechanical characteristics, degradation rate, microstructure, porosity, and so on, and are commonly employed in tissue engineering applications. Ref. [7] provides examples of synthetic polyesters with high structural long-term viability and mechanical strength.

Biomaterials are classified into four kinds. Metallic biomaterials [8] are among the most often utilized biomaterials. They are mostly employed in the application of fracture, dental, and knee implants due to their load-bearing capability and outstanding and prevalent mechanical characteristics. Titanium and its alloys, gold, silver, stainless steel, cobalt-chromium molybdenum, and other metallic biomaterials are examples. Ceramic biomaterials [9] are employed in dentistry as implant materials such as crowns, cement, and dentures. Based on bioactivity, ceramic biomaterials have a variety of biomedical uses. The emphasis of the latest studies is on producing nanostructure ceramic biomaterials. Ceramic biomaterials include calcium phosphate, hydroxyapatite, alumina, zirconia, and others. When compared to other biomaterials, polymeric biomaterials [9] are regarded as some of the best materials because they can be easily manufactured in various shapes, the secondary processing stage is easy, they are available at a reasonable cost, and they can

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easily be accessible at desired mechanical and physical properties. Nylon, polyester, and silicon are examples of polymeric biomaterials. It is a heterogeneous mixture of two or more biomaterials that are distinct or similar in terms of their physical properties as well as their chemical properties that makes up biocomposites or composite biomaterials [8,9]. This technology allows us to have a higher grade of material that is not demonstrated by a single material. Polysaccharides, proteins, sugars, lignins, and synthetic polymers are examples of composite biomaterials. Smart biomaterials are another type of revolutionary biomaterials that is driving ahead innovative medical treatments because of their capacity to adapt to variations in external stimuli or physiological parameters [10]. Smart hydrogels are among these biomaterials that are often used in drug delivery and tissue engineering applications [11,12]. Biodegradable hydrogels are frequently created using cleavable cross-linkers that may be dissipated by disentanglement, hydrolysis, or proteolysis in response to a particular stimulus [13]. Furthermore, a novel notion known as "four-dimensional (4D) bioprinting" was established in this framework, with time serving as the fourth dimension [14]. Another emerging type of smart material is electroactive polymers (EAPs), which have grabbed the interest of researchers as actuators for the construction of artificial muscles [15]. Nanostructured and nanomaterials biomaterials [16] have also been employed to replicate unique actuation and sensing capabilities in bioinspired robots.

Engineering human tissues to treat ailments is a multidisciplinary and very appealing subject of study in both the biotechnology industrial sector and academics. The majority of synthetic biomaterials for TE applications are generated from glycolide monomers, caprolactone, or lactic acid to make poly(L-glycolic acid), poly("-caprolactone), or poly(L-lactide), and/or their combination to develop copolymers, or physical mixing of these polymers [17]. Starch, cellulose, chitosan, collagen, alginate, hyaluronic acid, silk, fibrin, and variants of these polymers are also employed [18]. Over the past few decades, polymer scientific experts have been attempting to develop smart polymeric biomaterials [19] that imitate living tissues.

There are certain key elements to consider when developing and selecting biomaterial characteristics in order to avoid immune rejection with long-term use in the organism and have an impactful, distant future of biomaterial usage in the body [20]. Biological compatibility, also known as biocompatibility, is the "ability or capacity of a substance to be employed in close proximity to live tissue without producing damage or unfavorable impact on them" [4,21]. Implant materials must be non-toxic and not cause inflammatory or allergic responses, physical irritation, toxicity, mutagenesis, or carcinogenic effect in the human body [4,22]. Appropriate mechanical properties of biomaterials correspond to biomaterials that should be chosen based on mechanical strength depending on the location to be implanted and the function to be executed [23]. We should choose highly corrosion-resistant materials for bio-implants since low-corrosion materials might cause poisonous, allergic, and hazardous reactions in patients' bodies owing to the production of toxic and harmful metal ions such as Fe, Cr, Ni, Co, and Ti [24]. Corrosion can shorten the life of bio-implants and force surgical revisions, which can have an indirect impact on human life [25].

Modeling is required to create clinically applicable tissue engineering treatments [26]. It contributes significantly to the advancement of this discipline, which has been mostly empirically established to date. Modeling makes it possible to test hypotheses in a systematic way. Several experimental tissue engineering (TE) techniques and effects can be studied and improved using mathematical modeling [27]. The creation of successful tissue engineering procedures requires a strong association between modeling and experimentation [28], where devoted experiments enlighten models, which, in turn, offer advancements to in vitro protocols. Continuum models are used to describe the system's averaged behavior [29]. Continuum models certainly describe massive populations of cells and include the Navier–Stokes (NS) equations in fluid dynamics theory [30]. For this aim, continuum large or macro-scale models are more appropriate. Even in complex geometries, they give enough information on the chemical and mechanical environment [31–33]. Asymptotic or analytical solutions can be simplified, minimizing the need for numerical calculations and making comparisons to experiments easier [34]. The NS equations for mass conservation and momentum conservation are used in continuum models to characterize the flow [35,36].

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