BIOMATERIALS: THE SYNTHETIC MIMICKERS

My friend Ralph met with an accident and broke his femur bone. A few months later to my surprise I saw him hale and healthy. Was it a miracle? How was he able to walk at ease was the question running in my mind? Then he introduced me to the world of mimickers in the human body which are similar to the natural components of an entity.

Tissue engineering has recently emerged as an alternative strategy for bone defect repair and regeneration. In this strategy, a biodegradable scaffold is often utilized along with osteogenic cells and/or bone inducing factors to mimic the natural structure of the tissue. (Fig:1)

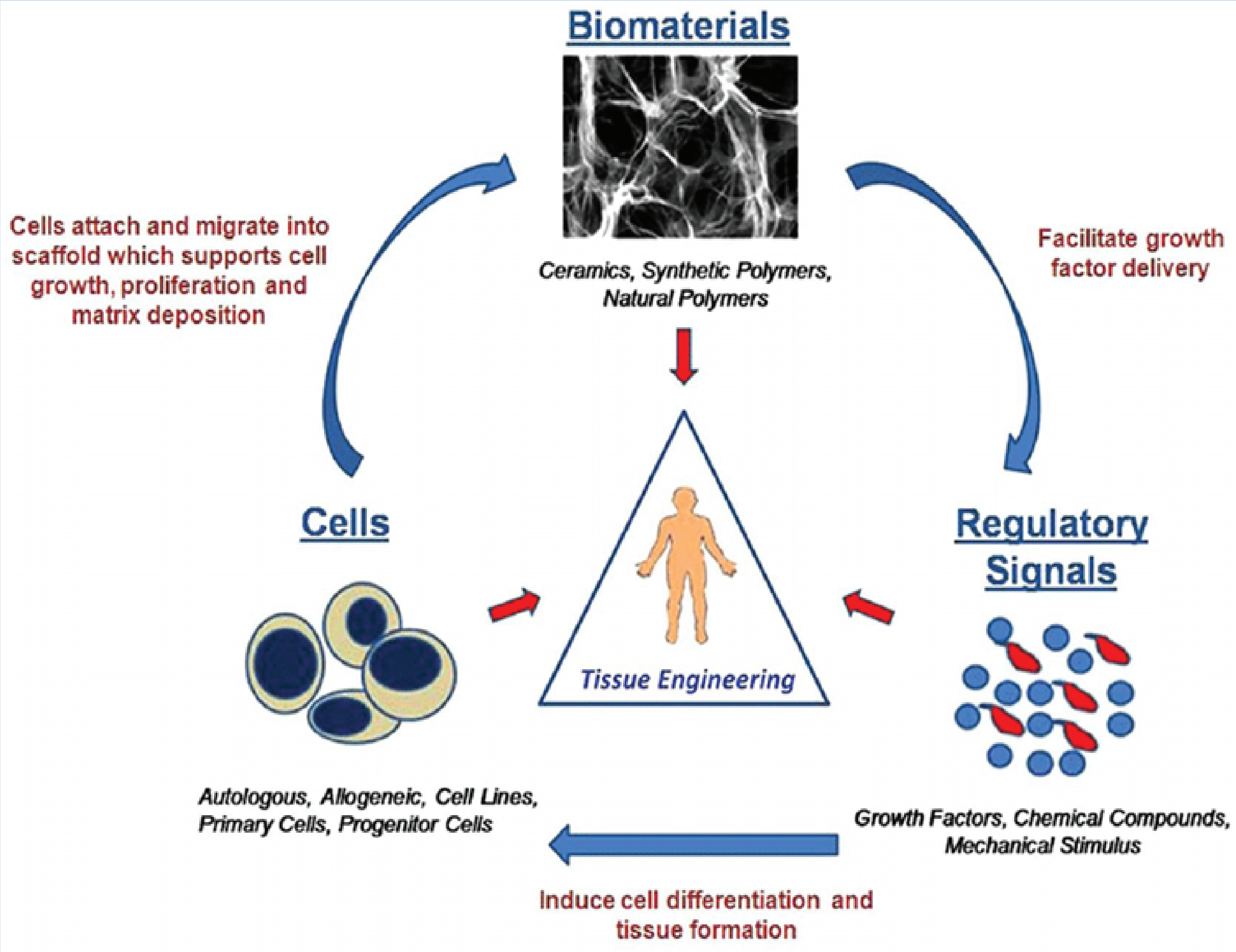

Fig. 1: The three essential components that make up the tissue-engineering triad.

Biomaterials could be defined as "implantable materials that perform their function in contact with living tissues". Biomaterials play a significant role in repairing/replacing the native body tissues or they act as a scaffolding material adopted to construct manmade tissues and organs. Biomaterials and tissue engineering sciences aim to develop materials which can be implanted in the human body to replace damaged tissues. Depending on the function to perform, they can be manufactured from very different materials.

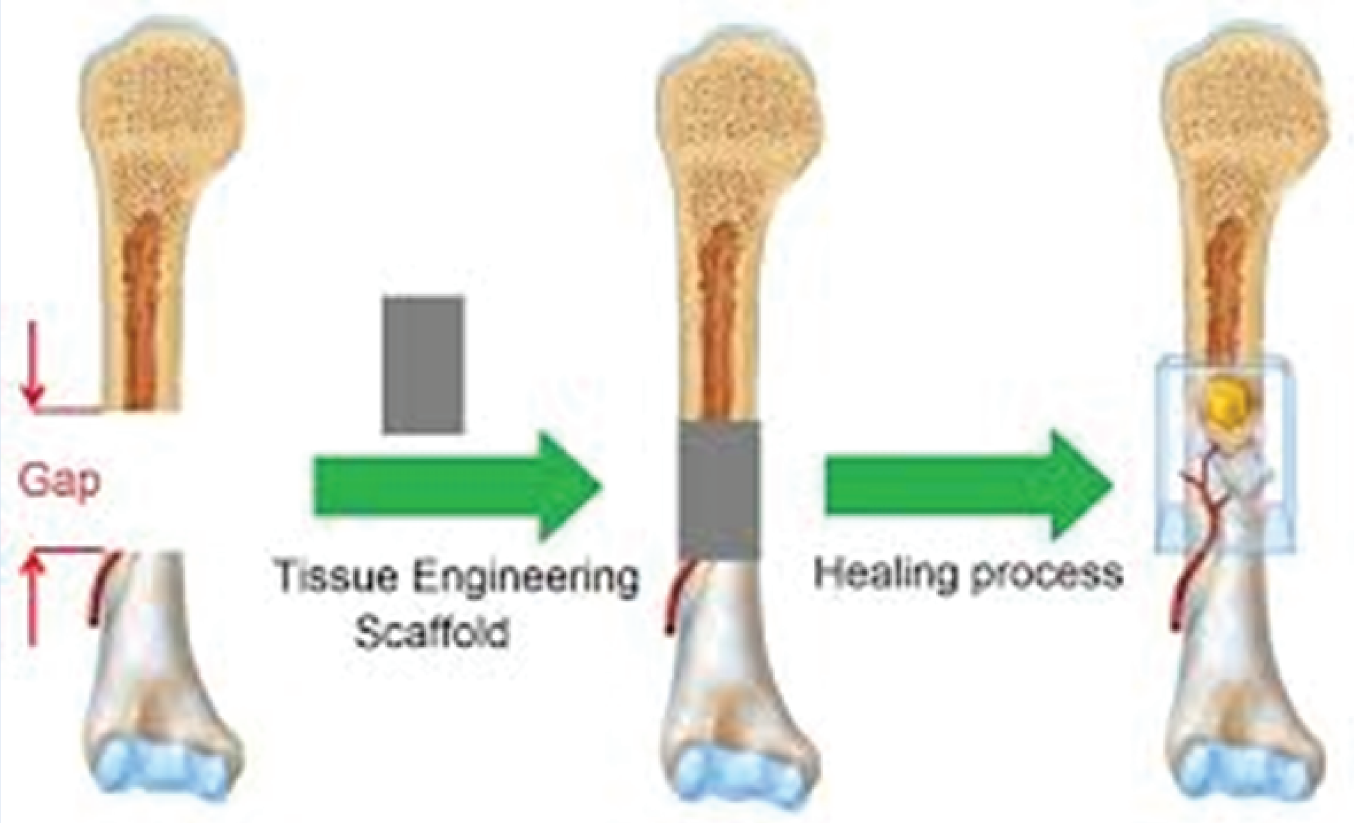

Fig. 2: Tissue engineering approach for reconstruction of large bone fractures [8]

The objective of this article is to have a short overview on Bioceramics, which is a synthetic biomaterial. Ceramic materials have been known to mankind since historic times for their diverse applications. The modern-day research in this area has shown great promise for their introduction in novel applicative areas. One such area of tremendous interest is medical science wherein the materials like bioceramics have shown great applicative prospects in bone and orthopedic implants, scaffolds for tissue engineering, and so on.

Bioceramics is a class of materials that is used for repairing or replacing damaged bone tissues. Depending on the application, bioceramics can directly interact with the surrounding tissue, either supporting tissue growth or inducing new tissue regeneration for bioactive ceramics. It can also remain inactive at the application site serving the purpose of mechanical load carrier as in the case of bioinert ceramics. The new frontiers of bioceramics not only deal with bone repair, but also enhance them when loaded with active biomolecules.[3]

Bioceramics are bioactive materials interacting with bone tissue when implanted inside bone to be totally integrated in several stages and replaced by the newformed bone. This property makes these materials particularly adapted to the transient transfection of bone cells, in particular osteoblasts and/or osteoclasts which are functionally deficient in some genetic diseases like osteogenesis imperfecta or aging diseases like osteoporosis. There is a number of genetic and acquired bone diseases clearly identified which could benefit from bioceramic transient transfection. (Fig:3)[3]

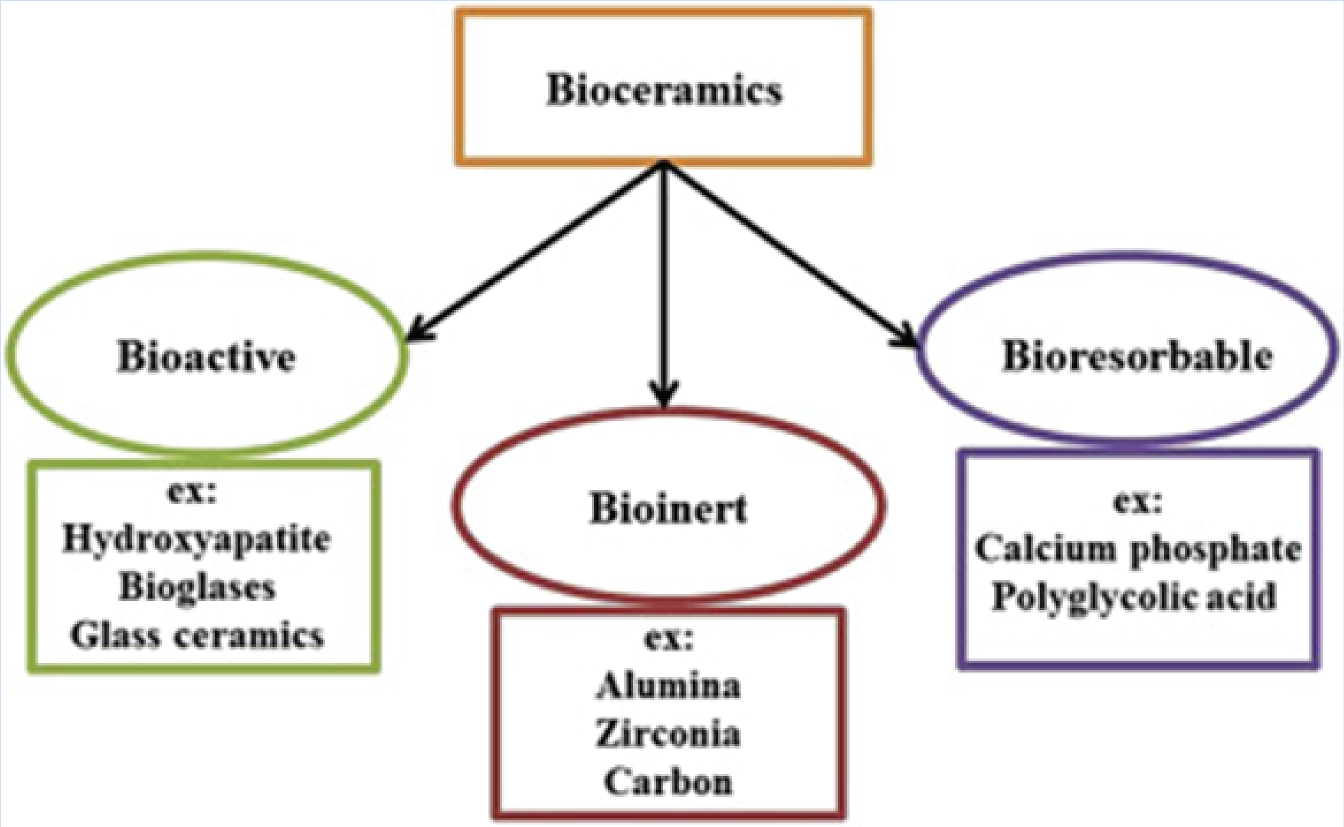

Fig:3 Categories of Bioceramics

Bioceramics are degradable and get replaced by bone following a process of resorption/reconstruction identical to that of natural bone. The ceramic grain boundaries are first resorbed. This degradation of the material allows the release of micro- or even nanoparticles that trigger biological reactions which can be useful for special applications. A good example of this is the transient induction of a foreign body reaction around the microparticles released by the calcium phosphate ceramics. The foreign body reaction is constituted by cells of monocytic origin involved in the immune response and in particular antigen presentation to the lymphocytes. Antigen expression in antigen presenting cells might enhance immune response. The degradability can thus amplify the foreign body and innate immune reaction.[3]

Fig:4 Bioceramics

APPLICATIONS OF BIOCERAMIC:

Ceramics are now commonly used in the medical fields as dental and bone implants. Surgical cements are used regularly. Joint replacements are commonly coated with bioceramic materials to reduce wear and inflammatory response. Other examples of medical uses for bioceramics are in pacemakers, kidney dialysis machines, and respirators.

CONCLUSION:

Progress in tissue engineering has led to the development of porous materials designed and manufactured to act as a scaffold for the growth of new tissue in order to restore the natural state and function of diseased parts of the body. Bioceramics have been successfully used within the human body by repairing and regenerating bone faster that would not restore by other means. These biomaterials are commonly used in orthopedic and dental surgery, but they are potentially suitable for a wide range of essential TE applications. TE has much to bring in respect to combining biomaterials, growth factors/bioactive molecules and cells. Innovative strategies present some of the current challenges in the field, and may constitute major breakthroughs in the future. Bioceramics offer desirable characteristics such as biocompatibility, chemical inertness in biological mediums and hardness, but they have low resistance to traction. Ongoing research involves the chemistry, composition, and micro- and nanostructure of the materials to improve the mechanical integrity of the bioceramics upon implantation, and appropriate porosity for the cellular adhesion, proliferation and differentiation.[9]

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