History of Regenerative Medicine

2

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2.1 History

Regenerative medicine is associated with engineering or regeneration of human cells, tissues, or organs and to restore or establish normal function [1]. Historically, regenerative medicine was first introduced by Kaiser in 1992, who described technologies which would impact the future of medicine [2]. Far earlier, in 1968 the first successful bone marrow transplantation in humans was performed [3]. Subsequently, this development grew and led to achieving further milestones in the fields of stem cells and transplantation.

Although regenerative medicine is considered as a novel target of medical research, the idea of creating artificial organs is not so recent. Already in 1938, Alexis Carrell, a Nobel Prize winner for his work on vascular anastomosis, and Charles Lindbergh, the first pilot who crossed the Atlantic sea alone, published the book *The Culture of New Organs* [4]. In 1954, the kidney was the first organ to be substituted in a human. No rejection reaction occurred due to the factor of identical twins [5].

The regenerative potential of body parts is a common phenomenon in nature; salamanders are able to restore an amputated limb in a few days. Even the human potential of regeneration was well known in ancient times, as described by the myth of the great Titan Prometheus: an eagle was eating his liver during the day and it regenerated itself completely overnight [6]. During the last centuries, regenerative medicine strove to construct artificial organs mimicking natural tissue by combining modulated cells with extracellular matrix-hybridized synthetic polymers that have produced biologically functioning artificial tissues [1]. These developments open new avenues for curing patients with malignant and impaired tissues.

In 1989, a book titled *Tissue Engineering* [7] was published with the first expressive definition of tissue engineering given by Robert Nerem:

> *Tissue engineering is the application of the principles and methods of engineering and the life sciences towards the fundamental understanding of structure/function relationships in normal and pathological mammalian tissues and the development of biological substitutes to restore, maintain, or improve functions.*

The evolution from tissue engineering into regenerative medicine was driven by intense developments in the financial, research, and political landscape. However, from a financial point of view, the last two decades, anticipated to bring the biotechnological revolution, were characterized by a disconnect between expectations and reality. Current strategies to pursue the objec-

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D. Duscher, M. A. Shiffman (eds.), *Regenerative Medicine and Plastic Surgery*,
https://doi.org/10.1007/978-3-030-19958-6_2

tives of regenerative medicine are based on three concepts:

- Cell-based therapy
- Either biological or synthetic materials to restore cells and tissues
- Implantation of scaffolds seeded with cells

Understanding innovative technologies is fundamental to developing successful approaches in the biotech sector and hence is influential in developing the field of regenerative medicine [8]. To date, only a multidisciplinary team, including doctors, biologists, bioengineers, surgeons, and chemists, is able to master all key steps in these revolutionary fields of regenerative medicine.

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