Regenerative Medicine
Gustav Steinhoff
Editor

Regenerative Medicine

From Protocol to Patient
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Regenerative Medicine is a fastly emerging interdisciplinary field of research and clinical therapies on the repair, replacement or regeneration of cells, tissues or organs in congenital or acquired disease. This new field of research and clinical development focussing on stem cell science and regenerative biology is just starting to be the most fascinating and controversial medical development at the dawn of the twenty-first century. It can be envisaged that this development will establish completely new molecular and cellular techniques for medical therapy. An early scientific trigger was set more than 100 years ago by the physiology of blood regeneration (Hall and Eubanks 1896) and successful vascular surgical techniques for organ transplantation (Carrel and Guthrie 1905). However, the clinical realization of allogenic blood transfusion lasted until the discovery of the blood group antigens (Landsteiner and Levine 1928) and successful routine allogenic organ and bone marrow transplantation even until the end of the last century.

Similar to the field of allogenic cell and organ transplantation it seems that Regenerative Medicine again condenses mankind’s visions, hopes, and fears regarding medicine: Hopes of eternal life and effective treatment of incurable disease as well as fears of misuse of technology and uncontrolled modifications of life are polarizing the scientific field. The development and public acceptance of new ethical and regulatory guidelines is a necessary process to support the further clinical development. Nevertheless, the vision of a new medicine using the regenerative power of biology to treat disease and restructure the organism is setting the aim for scientific, technological and medical development. Viewing the great expectations to restructure and regenerate tissue, organs or organisms the current attempts of scientist and physicians are still in an early phase of development.

The field of Regenerative Medicine has developed rapidly over the last 20 years with the advent of molecular and cellular techniques. This new textbook on Regenerative Medicine: From Protocol to Patient is aiming to explain the scientific knowledge and emerging technology as well as the clinical application in different organ systems and diseases. The international leading experts from four continents describe the latest scientific and clinical knowledge of the field of “Regenerative Medicine”. The process of translating science of laboratory protocols into therapies is explained in sections on regulatory, ethical and industrial issues. Patient needs are advocated by the proposition initiatives on the scientific development of new therapies.
This textbook is organized into five major parts: (I) Biology of Tissue Regeneration, (II) Stem Cell Science and Technology, (III) Tissue Engineering, Biomaterials and Nanotechnology, (IV) Regenerative Therapies, and (V) Regulation and Ethics.

We start with an overview on the History of Regenerative Medicine. This is followed by the part of Biology of Tissue Regeneration, which focuses on extracellular matrix, asymmetric stem cell division, stem cell niche regulation and stem cells during embryonic neurogenic development. The part on Stem Cell Science and Technology provides an overview as classification of stem cells and describes techniques for their derivation and culture. Basic properties of the cells are illustrated, and some areas of applications for these cells are discussed with emphasis on their possible future use in Regenerative Medicine.

The part of Tissue Engineering, Biomaterials and Nanotechnology focuses on the development of technologies, which enable an efficient transfer of therapeutic genes and drugs exclusively to target cells and potential bioactive materials for clinical use. Chimerism, multifunctionalized nanoparticles and nanostructured biomaterials are described with regard to the technological development of new clinical cell technology.

The part on Regenerative Therapies gives a survey on the clinical development in the different organ systems. Disease specific approaches of new therapies, application technology, clinical achievements and limitations are described. The part on Regulation and Ethics describes the current legislation for clinical translation as the ethical and juridical development in different countries. The need for patient propositions to foster the scientific development and clinical translation is described by Robert Klein, initiator of the California Initiative of Regenerative Medicine (CIRM).

The textbook is aiming to give the student, the researcher, the health care professional, the physician, and the patient a complete survey on the current scientific basis, therapeutical protocols, clinical translation and practised therapies in Regenerative Medicine. On behalf on the sincere commitment of the international experts we hope to increase your knowledge understanding, interest and support by reading the book.

Rostock, April 2010

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Literature

Carrel A, Guthrie CC. Successful transplantation of both kidneys from a dog into a bitch with removal of both normal kidneys from the latter. Science 1906; 9,23(584):394–395.

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