

New Horizons in Stem Cell Research

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Recently, stem cell technologies have drawn great interest in terms of regenerative medicine. Studies on stem cells have become one of the most productive and interesting areas of biomedical research, research that has demonstrated the increasing potential for using cutting edge technology in stem cell biology to develop new therapeutic options for many chronic fatal human diseases. The reason why stem cells show such potential is the capability of these cells to differentiate into various different lineages of cells to regenerate injured tissues and organs in the body. Therefore, this special issue has been published to review the clinical implication of using various stem cell types (from pluripotent to adult including direct differentiated cells) to heal patients suffering from chronic human disorders such as cerebrovascular diseases, chronic liver diseases, cardiovascular disorders, musculoskeletal diseases, and fatal cancers.

The emergence of human embryonic stem cell (ESC) lines is one of the most important achievements in the biological sciences during the previous century and has raised a broad scientific and social interest as it is believed embryonic stem cells can be utilized in the near future as a powerful source of material for cell transplantation in regenerative medicine. Studies with human ESC have enabled us to elucidate the gene expression patterns related to pluripotency and to initiate basic research allowing medical scientists to create induced pluripotent stem cells by several methods. Understanding genetic manipulation that can direct stem cells to develop into various lineages of terminally differentiated cells enable us directly to make differentiated cells from various cell sources.

In terms of clinical application, adult stem cells including mes-

enchymal stem cells have become a central focus in the real world. The establishment of an outstanding research laboratory for stem cell research and regenerative medicine involves translational research including the development of Good Manufacturing Practice (GMP) and clean room facilities in companies and medical schools. Further development and the establishment of systems for the production of autologous adult stem cells for clinical usage increase our capabilities for treating patients who have suffered from chronic diseases.

This review also focuses not only on the tremendous potential of stem cells and regenerative medicine including direct differentiation, but also the recent trend of using cancer stem cells for the successful treatment and management of intractable cancers.

First, Cha et al. will extensively review and summarize the recent progress in induced pluripotent stem cell (iPSC) generation and differentiation techniques that facilitate clinical application of iPSC for potential therapies in regenerative medicine [1].

Human ESC have been extensively studied over the last several decades. Recently, in addition to uses in cell replacement therapy, drug screening with embryonic stem derived cells has been highlighted in scientific and clinical fields. Han et al. will review the current development of alternative methods for enhancing the hepatic drug metabolizing functions of hepatocyte like cells derived from human embryonic stem cells used for drug screening and toxicity tests [2].

Among adult stem cells, mesenchymal stem cells are regarded as one of the most reliable cell sources for therapeutic use in various diseases. Kim will explain the characteristics of several kinds

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of placenta derived (PD)-mesenchymal stem cells (MSCs) and discuss recent studies of the therapeutic potential of PD-MSCs in the repair of liver injury and their utility in regenerative medicine. Although many problems remain to be solved, many studies suggest that human stem cell therapies, including PD-MSCs, are a promising new technology for intractable human liver damage/diseases [3].

Neurodegenerative diseases are genetic and idiopathic conditions that are characterized by progressive neuronal degeneration. Due to an increase in life expectancy, neurodegenerative diseases are emerging as the leading cause of death and disabilities and are rapidly becoming a tremendous socioeconomic burden. Stem cell-based therapy has furnished alternative options for the treatment of neurodegenerative diseases. Embryonic stem cells, induced pluripotent stem cells, and adult stem cells are all possible stem cell sources for neurodegenerative disorders. Yee et al. will summarize recent progress in developing treatments, outline the advantages and limitations of various stem cell technologies and discuss some current clinical trials of stem cell therapies for major neurodegenerative diseases [4].

Studies of MSCs stem cells from human bone marrow are ongoing world-wide. Eom et al. summarize the basic and therapeutic properties of MSCs, their therapeutic mechanisms of action, and potential transplantation routes for the treatment of chronic liver disease. He will also discuss several risks associated with the use of MSCs in therapy, such as their fibrogenic potential and capacity to promote pre-existing tumor cell growth [5].

Medical therapies and mechanical interventions for the treatment of myocardial infarction (MI) and ischemic heart failure have seen great progress. However, current therapies are only able to slow the progression to heart failure, but cannot stimulate regeneration to recover the loss of functional myocytes. Stem cell-based therapy is a novel modality that may be useful for the treatment of ischemic cardiac injury and heart failure wherein cardiac tissue can be regenerated to improve cardiac function, thus reducing morbidity and mortality for patients. Jeon will review and summarize the current evidence indicating the potential of stem cell therapy, focusing on the clinical trials conducted to date [6].

About 50 years ago, satellite cells were observed through electron microscopic inspection of skeletal muscle that showed a new kind of cell located between the basement membrane and the plasma membrane of muscle fiber. Recent studies have demonstrated that these satellite cell populations maintain an environment for

muscle stem cells with heterogeneous compartments of committed myogenic progenitors, non-committed satellite cells, and mesenchymal stem cells. This is a distinct community within the muscle tissue of cells with self-renewal and differentiation capacity suggesting a remarkable regenerative ability of skeletal muscles. Lately it has been proven that the satellite cell is capable of initiating muscle regeneration and is capable of self-renewal showing that its role is as a true muscle stem cell. Therefore, stem cell therapy using satellite cells is proposed to be an ideal therapy for muscular dystrophies caused by deficiency of specific muscle protein resulting in muscle degeneration. Especially, Duchenne Muscular Dystrophy (DMD), which is caused by mutations of the dystrophin gene, has been targeted in a number of investigations. In the review by Yang et al., satellite cell characteristics, regulation of cell function, and stem cell therapy for DMD and the progress in recent clinical trials will be discussed [7].

Recent advances in molecular biology have furnished reprogramming methodologies that give the ability for direct reprogramming of terminally differentiated cells to furnish induced pluripotent stem cells (iPSC), and iPSC are rapidly becoming one of the most important cell sources for various scientific fields and are hoped to be a source for stem cell therapies. Lee will discuss updates concerning production and uses of iPSC [8].

Advance in the understanding of stem cells (SCs) and the isolation of tissue specific SC have provided significant development for utilizing SC for regenerative medicine. Recently, researchers in SCs and cancer biologists have demonstrated a small subpopulation of cancer cells, named cancer stem cells (CSCs), with similar properties. These properties include an indefinite self-renewal potential and a sharing of similar regulatory signaling pathways with normal SCs. It is hypothesized that this is because the origin of CSCs is from the mutation of normal SCs. It is thought then that CSCs in solid tumors may organize like the normal SCs in a similar cellular hierarchy within these cancer tissues. The clinical features of cancer stem cells will be reviewed by Song et al. [9].

Despite the technical advances in science and the continuing progress in stem cell research, still, there are many obstacles present on the complicated way to clinical application of stem cells. To overcome the complexity of stem cell research in clinical applications. A multidisciplinary team of biologists, surgeons, and medical doctors will be needed.

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