Research applications of stem cell

Science, Biology

The ability to self-renew and differentiate into mature cell types makes stem cells attractive targets of basic research. Most research is involved in the identification of differentiation factors, genetic as well as environmental signals that exist in the stem cell niche8-9. Increasing number of clinical applications is being developed in the following areas.

Amyotrophic Lateral Sclerosis

ALS is progressive neuromuscular disease, characterized by loss of motor neurons in the brain and spinal cord. The treatment strategies only alleviate the symptoms. Studies aim to regenerate lost motor neurons in the brain and spinal cord with bone marrow stem cells and iPS. Experiments with prenatal stem cells and mesenchymal stem cells feature in the early phase of clinical trials.

Spinal Cord Injuries

Severe accidents, falls, and birth defects like spina bifida cause serious injury to spinal cord. In several cases, nerve fiber bundles are severed, leading to paralysis. Currently, clinical investigations aim to use adult stem cells to regenerate new nerve cells and trigger growth of severed nerve fibers. Investigations to transplant support cells that wrap nerves with myelin sheath are also being carried out. In the absence of existing therapies, employing stem cells to improve nerve function is critical.

Eye Diseases

Injuries to cornea, retina or optic nerve and disease conditions such as age-related macular degeneration, glaucoma and retinitis pigmentosa result in vision loss. Improved vision was noticed in animals with macular degeneration when transplanted with retinal pigment epithelial cells derived

from embryonic stem cells limbal stem cells and retinal stem cells have shown positive results in regenerating human corneal tissue.

Wound Healing

Conventional skin grafts fail to restore the complete composition of dermis lost due to injuries, genetic disorders, and burns10. Basal layer stem cells derived skin grafts are approved for clinical use, which are mainly used for large burns. Stem cells promote better and faster healing of the burn wounds and decrease the inflammation levels with less fibrosis and scar progression.

Cardiovascular Diseases

Most cardiovascular disorders are characterized by ischemia and heart muscle injury that result in arrhythmias, hypertrophy and congestive heart failures. Standard treatments include surgeries repairing blocked arteries, medications reducing fluid retention and lifestyle changes. However, none of them can regenerate the heart tissue. Stem cell therapies, under investigation, aim to restore lost function of heart tissue and blood vessels and reduce clinical cardiac events.

Autoimmune Disorders Type 1 Diabetes

Hyperactivity of body’s immune system destructs insulin-producing pancreatic beta cells in Type 1 diabetes patients. While insulin injections are effective treatment options, they fail to provide a consistent and right amount of insulin required throughout the day resulting in unstable levels of glucose in the blood. Cells derived from hematopoietic stem cells are being investigated to replenish beta cells. Another study is reprogramming sperm

stem cells into embryonic-like cells, which further differentiate into beta cells of pancreas.

Multiple Sclerosis

Multiple sclerosis is characterized by a chronic inflammatory diseases in brain or spinal cord triggered by body own immune system. Majorly, myelin sheath of the nerves is damaged which compromise nerve signals. There is no cure for multiple sclerosis; however, medications are used to treat symptoms. Bone marrow stem cells and neural stem cell derived oligodendrocytes are being investigated to regenerate neurons with a myelin sheath. In addition, investigations to reduce immune system function are also being carried out.

Arthritis

Arthritis is characterized by chronic pain, inflammation of the joints and stiffness. There are many etiological reasons; some of them include destruction of cartilage by the immune system. Current medications majorly reduce pain and inflammation. Stem cells have a potency to differentiate into chondrocytes, which makes cartilage. Investigations are underway to make patient-derived chondrocytes for transplantation.

Disease Modeling & Drug Screening

Stem cells are evolving as suitable models to study the efficacy of drugs since they combat the shortcomings of transformed cell line systems and bypass the ethical challenges of using animal models. Now pharmaceutical industries are increasingly focusing on stem cells for screening drugs and creating “ disease-in-a-dish” cellular models. Some of the applications are as

follows: Human embryonic stem cells derived cardiomyocytes (hESC-CMs) provide human model for predictive cardiac toxicity, reducing drug development costs.

Induced pluripotent stem cells derived from patients resemble pathogenic conditions in-vitro and could increase the success rate of drug screening and accelerate drug development process24. Differentiated neuronal cells are similar in genetics and biological content to human brain cells compared to animal disease models. These neuronal cells derived from stem cells are employed for cell viability, calcium response and neurite outgrowth assays.

Cell Research Challenges

Stem cells are an evolving area of research that is riddled with multiple unknowns.

Immunological Rejection

A major challenge with stem cell transplants is rejection by the recipient’s immune system. To evade tissue rejection, patients undergo immunosuppressive treatment, that makes them susceptible to microbial infections27. Inducing pluripotent cells directly from the patient’s cells to generate graft or tissue may resolve the problem associated with immunological rejection to an extent. However, low frequency of induced pluripotent stem cells is a major hurdle.

Behavior

Embryonic stem cells divide indefinitely and could induce tumor growth. Somatic cells can directly reprogram to specialized cells without the intermediate pluripotent state. While induced pluripotency of somatic cells

can bypass the pluripotent state, limited proliferative and lineage potential of resulting cells limit the scope28. SafetyStem cells being used in cell therapy or regenerative medicine could be exposed to microbes, which eventually could cause infectious diseases28. The necessary preliminary diagnostic test must be developed before the treatment. In addition, retaining intended biological activity before treatment is crucial for the success of the therapy. Systematic protocols need to be developed for isolation, testing and transplantation of stem cells, to ensure patients safety.

The awareness and interest of stem cell biology are expanding significantly. Over the past decade, several studies focused on understanding the complex nature of stem cell types. Investigations improving stem cell efficacy and stem cell migration29are underway. Apoptosis of engineered stem cells, once they have performed their role, is an active area of study30. While research on applications of stem cells in tissue regeneration, genetic diseases, and cancer is growing there is still a long way before we witness widespread use of stem cells in therapy. Newly discovered gene editing technologies like CRISPR could advances stem cell research and offer enormous promise in treating multiple disorders.