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REVIEW ARTICLE

# Stem Cells

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## ABSTRACT

Stem cells are blank or undifferentiated cells found in the human body that have the tendency to develop into many different cell types to carry out different functions. Most of the differentiated cells are present in human body. That means they are built to function in a particular organ system and carry out a specific function. A red blood cell, for example, is designed to carry oxygen, while a white blood cell is designed to fight off disease. These differentiated cells result from the process of cell division, a process that begins with undifferentiated stem cells.

**Keywords:** Regeneration, Research, Stem cell, Treatment.

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## INTRODUCTION

Stem cells are undifferentiated cells that have the ability of proliferation, regeneration, conversion to differentiated cells, and tissue production. Regeneration means that these cells have the ability of asymmetric division through which one of the resulting cells remains as stem cell, while another cell, which is called daughter cell, becomes one cell of germ layer. Stem cells may remain inactive for a long time until they enter cell division again.[1]

Stem cells are defined by two characteristic properties: differentiation and self-renewal. Differentiation is the process where unspecialized cells acquire specific cellular traits, which convert them into specialized cell types. The ability of stem cells to differentiate into all of the specialized cell types of a specific cellular lineage is a key property of stem cells. For example, a blood stem cell is considered a stem cell because it has the ability to differentiate into all the specialized cell types of the blood cell lineage including red blood cells, white blood cells, and platelets. To think of it in another way, all the specialized cells of the blood system arise (or "stem") from a population of blood stem cells.[2]

The differentiation of stem cells into specialized cells is not an immediate process, but rather differentiation occurs in a series of stages in which cells become more restricted in the types of specialized cells they can give rise to at each stage. As stem cells differentiate, they are said to become committed, which means they can no longer differentiate into cell types outside of the specified lineage. The number of different specialized cell types that a stem cell can give rise to defines the potency of a stem cell. In this regard, stem cells can be broadly classified as totipotent, pluripotent, or multipotent.[3]

### Historical Perspective

Major changes in regenerative medicine (replacement of damaged or diseased cells and tissues with new cells and tissues) have taken place due to advances in stem cell technologies. Some stem cell therapies are in existence for over 50 years. First successful bone marrow transplant was done in 1956 on a leukemia patient. Bone marrow contains adult-derived hematopoietic stem cells (able to regenerate tissues similar to the specialized tissues in which they are found). Embryonic stem cells are believed to have greater potential. This line of stem cell research has been the most controversial. For the first time in 1981, the researchers could isolate stem cells from mouse embryos. More accurate studies on the biology of mouse stem cells led to discovery of methods for separation of stem cells from the human embryo in 1998.[4,5]

The 2007 Nobel Prize in medicine was awarded to Mario R Capecchi, Martin J Evans, and Oliver Smithies for their discoveries of the principles for introducing specific gene modifications in mice by the use of embryonic stem cells.

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## CLASSIFICATION OF STEM CELLS

### Classification of Stem Cells Based on Potency

Stem cells can be classified by the extent to which they can differentiate into different cell types. These five main classifications are

1. *Totipotent stem cells*: They have the ability to differentiate into all possible cell types. Examples include the zygote formed at egg fertilization and the first few cells that result from the division of the zygote.
2. *Pluripotent stem cells*: These are found in embryos and can give rise to all the cells found in the human body cells as diverse as those found in the brain, bone, heart, and skin.
3. *Multipotent stem cells*: These are found in adults or in babies' umbilical cords and have a more limited capacity. Their development is limited to the cells that make up the organ system that they have originated from. For example, a multipotent stem cell in the bone marrow can develop into a red blood cell, a blood platelet, or a white blood cell, but not into a skin cell or brain cell.
4. *Oligopotent stem cells*: These types of stem cells have the ability to differentiate into a few cells. Examples include (adult) lymphoid or myeloid stem cells.
5. *Unipotent stem cells*: These have an ability to only produce cells of their own type, but have the property of self-renewal required to be labeled as a stem cell. Examples include (adult) muscle stem cells.

### Classification of Stem Cells Based on Their Sources

The easiest way to categorize stem cells is by dividing them into two types: Early or embryonic and mature or adult. Early stem cells, often called embryonic stem cells, are found in the inner cell mass of a blastocyst after approximately 5 days of development. Mature stem cells are found in specific mature body tissues as well as the umbilical cord and placenta after birth.[6,7]

1. *Embryonic stem cells*: Embryonic stem cells are self-replicating pluripotent cells that are potentially immortal. They are derived from embryos at a developmental stage before the time of implantation would normally occur in the uterus.[2] The embryos from which human embryonic stem cells are derived are typically 4 or 5 days old and are a hollow microscopic ball of cells called the blastocyst.[8,9]
2. *Adult stem cells*: Adult stem cells are undifferentiated totipotent or multipotent cells, found throughout the body after embryonic development, that multiply by cell division to replenish dying cells and regenerate damaged tissues. The primary roles of adult stem cells in a living organism are to maintain and repair the tissue in which they are found. Unlike embryonic stem cells, which are defined by their origin (the inner cell mass of the blastocyst), the origin of adult stem cells in some mature tissues is still under investigation.[10,11]

## APPLICATIONS OF STEM CELLS

- *Traumatic brain injury*: Patients treated with stem cells usually observe improvements in cognition and memory, speech and swallowing, and balance.
- *Muscular dystrophy*: Patients treated with stem cells usually observe improvements in muscle mass and strength, motor function, and balance.
- *Retinitis pigmentosa*: Patients treated with stem cells usually observe improvements in field of vision, color vision, light perception, and nystagmus.[12]
- *Optic nerve atrophy*: For optic nerve atrophy and optic nerve injuries patients, this treatment can restore fibers through missing optic nerve cells and improve eyesight.[13]
- *Autism*: Patients treated with stem cells showed visible signs of improvement in social interaction, verbal and nonverbal communication.[14]
- *Multiple sclerosis*: Patients treated with stem cells observe improvements in balance, coordination, sensitivity, bladder and bowel control.
- *Spinal cord injury*: Patients treated with stem cells achieved improvements in bowel and bladder control, sexual function, sensation, and motor function.[15]
- *Ataxia*: Patients have experienced remarkable improvements, such as speech and cognition, increased mobility, better balance and coordination.[16]
- *Chronic kidney disease*: Patients treated with stem cells usually observe improvements in blood urea nitrogen and creatinine levels normalizing filtration.[17]
- *Optic nerve abnormalities*: Stem cell treatments have been shown to help a wide range of medical conditions, such as visual impairments, autoimmune and neurological diseases.
- *Spinal muscular atrophy*: Patients treated with stem cells observe improvements in neuropathic pain, muscle tone and strength, tremors, and fatigue.[15]
- *Stroke*: Stroke patients treated with stem cells usually observe improvements in motor function, muscle tone, spasticity, speech, balance, and coordination.
- *Liver cirrhosis*: Patients treated with stem cells usually observe improvements in ascites, vatical bleeding, improved liver function, and associated symptoms.
- *Primary lateral sclerosis*: Stem cell transplantation is a potential therapeutic strategy via cell replacement.
- *Cerebral palsy*: Cerebral palsy patients treated with stem cells observe improvements in swallowing, speech, coordination, vision, epilepsy, and muscular strength.[12]

- *Not listed medical conditions*: Stem cell treatments have been shown to help a wide range of medical conditions, such as visual impairments, autoimmune and neurological diseases.[9]

## CONCLUSION

Stem cells provide unmatched opportunities for applying postgenomic technologies to understand cellular development, functional differentiation, and disease. Out of this should emerge medical benefits in the form of new biomarkers, improved drugs, and ultimately cell replacement therapies. Crucially, stem cells also hold the key to understanding pluripotency which might eventually enable scientists to convert one type of specialized cell into another cell type for treatment of a disease or injury in the same patient. For Europe to participate fully in, and reap the rewards of, stem cell research will require supranational cooperation in both research and regulation.

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