

Stem Cells: Significance and Preservation

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ABSTRACT

Stem cells are remarkable unspecialized cells with the unique ability to self-replicate and, under certain conditions, differentiate into various cell types. These cells play a crucial role in the development and repair of tissues and organs within multicellular organisms. Researchers categorize stem cells based on their origin and potency, leading to a deeper understanding of their potential. In today's context of rising antimicrobial resistance, stem cells have emerged as a vital area of exploration for scientists looking for alternative treatment methods. The ongoing research and experiments focused on stem cell-mediated therapies hold immense promise due to the unique properties of these cells. Such therapies are showing potential for treating previously untreatable illnesses and genetic defects. Despite the challenges and debates surrounding stem cell research, these therapies are increasingly being recognized as essential in advancing medical science. This review will delve into the fascinating world of stem cells, exploring their various types and the exciting future applications they may offer.

KEYWORDS: *stem cell, Cryopreservation, stem cell therapy.*

INTRODUCTION

Stem cells are undifferentiated cells with the ability to self-renew and develop into various cell types. They can be pluripotent, like embryonic and induced pluripotent stem cells, which form tissues from all three germ layers, or multipotent, like mesenchymal stem cells, which form specific tissues¹. Stem cells have important roles in therapy and research, but face challenges such as ethical concerns and the risk of tumor formation. Stem cell therapy is rapidly advancing in India, offering innovative treatments for various medical conditions. It effectively repairs, replaces, or regenerates cells, tissues, or organs affected by diseases like neurological disorders, cardiovascular issues, and diabetes. The country has numerous specialized centers and research institutions conducting studies and trials to explore stem cell applications. Additionally, strict government regulations ensure the ethical and safe use of stem cells in therapy.²

Stem Cells Unveiled: The Future of Medicine

Stem cells are commonly known as the body's "master cells" because of their remarkable capacity to develop into various specialized cell types. Unlike typical cells, which have fixed roles-such as red blood

cells that transport oxygen and muscle cells that facilitate movement-stem cells are versatile and unspecialized. This unique characteristic allows them to not only renew themselves through cell division but also to differentiate into other cell types when the body requires it. This adaptability makes stem cells a vital component in research and potential treatments for various medical conditions. Stem cells contribute to natural healing and play an important role in regenerative medicine³. Stem cell banking through long-term storage of different stem cells represents a basic source to store original features of stem cells for patient-specific clinical applications. This study concludes that Stem cells can heal the body, promote recovery, and offer an enormous amount of therapeutic potential. Cord blood holds promise for future medical procedures. Many scientists are still studying more ways to treat more diseases with cord blood. For example, many researchers are using patients' own cord blood in trials for cerebral palsy and Hypoxic ischemic encephalopathy⁴.

Stem cell preservation is an emerging strategy in disease prevention and regenerative medicine. With their ability to self-renew and differentiate, stem cells

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are increasingly used to treat various conditions, such as blood disorders, heart disease, neurodegenerative illnesses, and certain cancers. Advances in collection methods and preservation technologies, particularly using umbilical cord blood and tissue, have improved accessibility and ethical acceptability. While challenges remain regarding clinical consistency, safety, and optimal use, ongoing research continues to refine these therapies. Overall, stem cell preservation offers valuable potential for future personalized medicine and regenerative healthcare⁵

Key Reasons for the Significance of Stem Cells.

- 1. Self-renewal:** Their ability to divide and produce more stem cells ensures their population remains stable.
- 2. Differentiation:** They can transform into specialized cell types, such as blood, nerve, muscle, or bone cells.

This unique combination of abilities is not found in other cell types. Stem cells are present in every tissue and play a crucial role in medicine. Currently, they are used to treat conditions like leukemia, lymphoma, sickle cell anemia, and some immune disorders.

Researchers are also investigating their potential to repair damage from spinal cord injuries, heart disease, diabetes, orthopedic issues, and neurodegenerative diseases such as Alzheimer's and Parkinson's.⁶

Sources of Stem Cells

Stem cells derive from several crucial sources, each offering significant medical benefits:

- 1. Embryonic Stem Cells (ESCs):** Sourced from early embryos (3-5 days old), these pluripotent cells can develop into nearly any cell type, making them essential for tissue repair, though their use faces ethical limitations.
- 2. Somatic Stem Cells:** Found in bone marrow and skin, these multipotent cells differentiate into specific cell types, such as blood cells, and are vital for treating blood cancers and immune disorders through transplants.
- 3. Induced Pluripotent Stem Cells (iPSCs):** Created by reprogramming adult cells, these cells emulate embryonic stem cells without ethical concerns, providing invaluable research and potential personalized therapies.
- 4. Perinatal Stem Cells:** Collected from umbilical cord blood and tissue, these easily obtained cells are rich in hematopoietic and mesenchymal stem cells, crucial for future treatments.
- 5. Fetal Stem Cells:** While less commonly used, these cells from developing fetuses are considered

ethically safer than ESCs and hold strong potential for therapy and research⁷

Stem Cell Preservation: A Smart Investment for the Future

Stem cell preservation involves collecting, processing, and storing stem cells for future medical treatments. The primary method used is cryopreservation, where stem cells are frozen at low temperatures to maintain their viability.

Key sources for preservation include:

- **Umbilical cord blood:** Rich in hematopoietic stem cells, collected at birth.
- **Umbilical cord tissue:** Provides vital stem cells, also harvested at birth.
- **Bone marrow:** Crucial for various blood-related treatments.
- **Peripheral blood:** Sourced from the bloodstream for specific therapies.
- **Fat (adipose) tissue:** Contains versatile mesenchymal stem cells.

In conclusion, stem cell therapy represents a promising and dynamic field, with ongoing research and innovation driving new advances in regenerative engineering and cell-based treatments at the cellular level.⁸

Steps of Preserving Stem Cells

Step 1: Collection

Stem cells are decisively collected from umbilical cord blood and tissue immediately at birth or sourced from bone marrow, peripheral blood, or fat tissue.

Step 2: Processing

In the laboratory, the sample is expertly separated, tested for viability and infections, and mixed with a cryoprotectant, such as dimethyl sulfoxide (DMSO), to ensure their integrity.

Step 3: Cryopreservation

The stem cells are cooled systematically to approximately -80°C before being transferred to liquid nitrogen at around -196°C for optimal long-term storage.

Step 4: Storage

These cells are securely stored in regulated banks, where their viability is maintained for decades under stringent temperature control and monitoring

Step 5: Retrieval

When needed, the cells are skillfully thawed, retested, and rigorously prepared for immediate use in medical treatments.⁹

Types of Stem Cell Banks

Stem cell banks are critical resources for the collection, processing, and storage of stem cells. Here are the main types you should know about:

1. Public Stem Cell Banks:

a. These banks expertly collect and store donated stem cells for public use, making them readily available to patients in need of transplants for conditions such as leukemia. Donations are altruistic and free, ensuring broad accessibility.

2. Private Stem Cell Banks:

a. Private banks empower families to securely store their child's umbilical cord of blood and tissue for personal use, typically for a fee. This option acts as a proactive form of biological insurance, ensuring families have access to vital stem cells if medical needs arise, even though the actual demand may be low.¹⁰

3. Research Stem Cell Banks:

a. These specialized banks are dedicated to collecting stem cells for scientific research. They provide invaluable access to various stem cell types, including embryonic and induced pluripotent stem cells (iPSCs), driving advancements in disease understanding and potential therapies.

4. Cord Blood Banks:

a. A focused subset of public and private banks, cord blood banks specifically preserve umbilical cord blood, which is rich in hematopoietic stem cells. They can operate as public donations or private storage options for families, ensuring the availability of these critical cells.

Significance of Stem Cells

1. Effective Treatment for Serious Diseases:

Preserved stem cells from umbilical cord blood are proven to treat over 80 serious conditions, including cancers and blood disorders, and are essential for restoring immune function after chemotherapy.

2. Personal Compatibility is Key:

Stem cells collected from an individual provide a perfect genetic match, significantly reducing the risk of complications and ensuring immediate access when treatment is necessary.

3. Potential for Family Use:

These preserved stem cells can be beneficial for siblings or close relatives, with partial matches often being clinically acceptable.

Expanding Medical Applications:

Ongoing research is paving the way for new therapeutic uses of stem cells, addressing conditions like cerebral palsy, diabetes, and heart disease.

4. Advantages of Cord Blood Stem Cells:

Cord blood stem cells are younger and less immunologically experienced, making them safer for transplantation and drastically reducing the risk of complications.

5. Long-Term Viability:

When stored under cryogenic conditions, stem cells can remain viable for decades, retaining their therapeutic potential even beyond 20 years.

6. Flexible Storage Options:

Families have the freedom to choose between local or international storage facilities, and stem cells can be safely transported in frozen form whenever needed.

7. Quick Preservation Process:

The collection process is efficient, taking just minutes, while processing and freezing can be completed within hours to a couple of days.¹²

Stem Cell Preservation Charges

The cost of preserving stem cells typically ranges from ₹50,000 to ₹1,00,000. This pricing can vary based on several factors:

1. **Location:** The city and the specific hospital where the procedure is performed can significantly influence the cost.

2. **Type of Facility:** The preservation facility and the quality of its equipment play a role in determining the price.

3. **Collection and Storage Methods:** The methods used for collecting and storing stem cells impact the overall charges.

4. **Expertise of Specialists:** The experience and qualifications of the specialists overseeing the process also affect the cost.¹³

Conclusion

In today's era of preventive care, stem cell banking is a lasting investment in health. Stem cell preservation is a proactive way to secure future health. As medical technology advances, these cells could offer access to life-changing treatments. Banking stem cells at birth gives your family a valuable resource for potential therapies. Selecting a trusted stem cell bank and understanding the benefits helps parents make informed choices.

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