

# Emerging trends in Stem Cell Therapy: Types, Clinical Benefits, Technologies, and Future Prospects



Rajni Dubey\* & Bhaskar Kumar Gupta

School of Pharmacy & Research, People's University Bhopal, Madhya Pradesh, India

rajnidubey11@gmail.com

## **Introduction:**

The process of introducing healthy new cells into a patient's body to take the place of diseased or damaged ones, altering the function of the patient's cells through the expression of factors or direct interaction, or removing disease-causing or dysfunctional cells with the help of immune cells is all referred to as cell therapy. Charles-Édouard Brown-Sequard, a pioneer in hormone therapy at the time, attempted to counteract the signs of aging through injections of animal testicle extracts in the year 1889. Today, cell therapy is moving forward with ongoing studies of its clinical safety and effectiveness. Stem cell and non-stem cell-based unicellular or multicellular treatments are combined in cell therapy. It typically makes use of allogeneic or autologous cells; could make use of genetic engineering or other manipulations; and can be used topically, as injectables, infusions, scaffold-free systems, or as injectables. The various types of cell therapies, including stem cell-based and non-stem cell-based cell therapies, provide an overview of their nature as well as techniques for isolation and characterization. Cell therapy spans multiple therapeutic areas, including cancer therapy, immunotherapy, and regenerative medicine.<sup>1,2</sup>

## **Stem-cell-Based Therapies:**

### **Overview of Stem Cells:**

Unlike the other cells in the body, stem cells have the special and unique capacity to transform into practically any form of cell. Stem cells or their derivatives are utilised in cell therapy to create new tissue or to encourage the healing response in damaged cells.

Stem cells are unspecialized, self-renewable cells that are prepared to develop into any cell type and/or as many cell types as needed. They may be found in both adult and embryonic tissues of an organism. External cues, such as physical contact between cells, paracrine secretions from surrounding tissues, and tissue type, as well as internal signals like genes and epigenetics, all have an impact on stem cell specialisation (embryonic cell origin). Depending on the kind of stem cells, in silico gene expression analysis can identify stem cell specialisation [for example. Bioinformatic test called Pluri-Test<sup>3</sup>

Stem Cells Used or Targeted by Cell Therapy Stem cells used or targeted by cell therapy can be grouped into three categories:

- Pluripotent stem cells
- Adult stem cells
- Cancer stem cells

Pluripotent stem cells: - PSCs include embryonic stem cells (ESCs), found in the inner blastocyst cell mass of preimplantation embryos; epiblast stem cells (EpiSCs) and embryonic germ cells (EGCs), found in post-implantation embryos; and induced pluripotent stem cells (iPSCs), derived from direct reprogramming of postnatal/adult somatic cells in vitro. PSCs give rise to all cell types except extraembryonic placental cells as shown in figure 1.

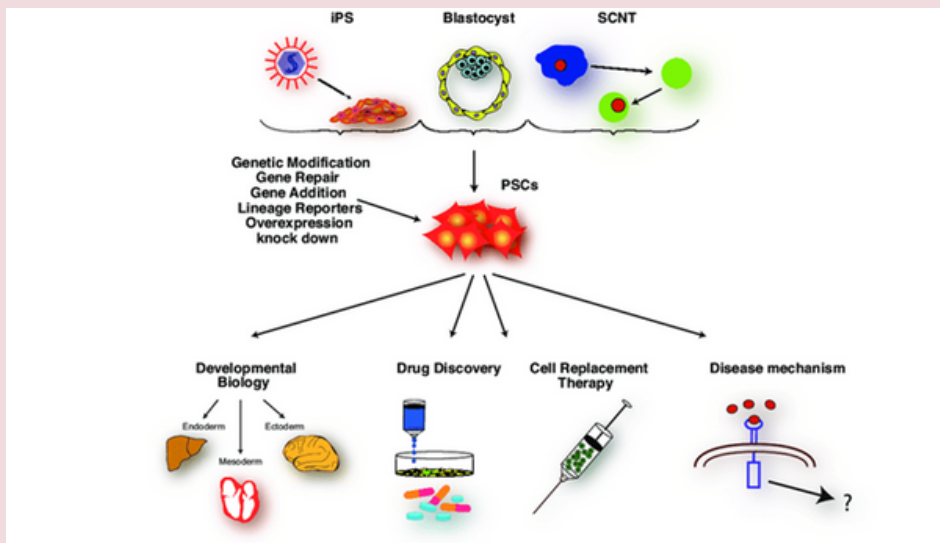


Figure 1: Pluripotent stem cell sources and their application.

Adult stem cells: Adult stem cells are uncommon, undifferentiated cells found among differentiated or specialized cells in mature body parts. ASCs, which have less self-renewal and differentiation capability than PSCs, restore lost cells or contribute to cell repair or growth by giving rise to precursor or progenitor cells and, eventually, differentiated cells. Hematopoietic stem cells (HSCs), skin stem cells (SSCs), neural stem cells (NSCs), and mesenchymal stem cells are examples of ASCs (MSCs) as shown in figure 2.

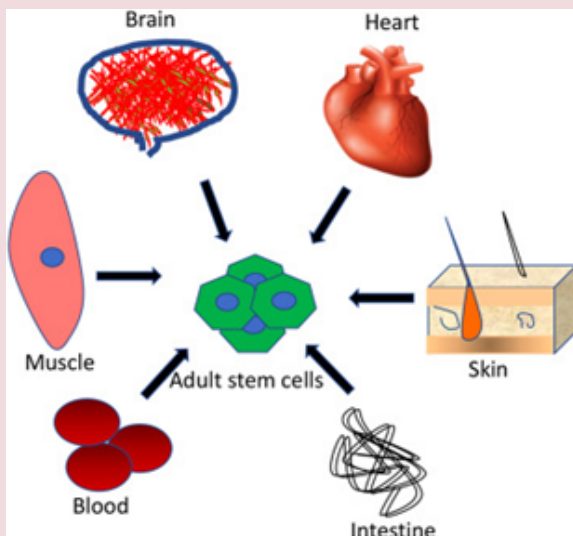


Figure 2: Adult stem cell

Cancer stem cells: CSCs, or tumor-initiating cells, are seen in solid and blood cancers and are thought to arise from normal stem or progenitor cells by a variety of methods including mutations, gene transfer, epigenetic modifications, and microenvironmental variables. CSCs have self-renewal, differentiation, metastasis, and immunosuppressive qualities and are involved in cancer development, metastasis, recurrence, and resistance to chemotherapy and radiation. as shown in figure 3.

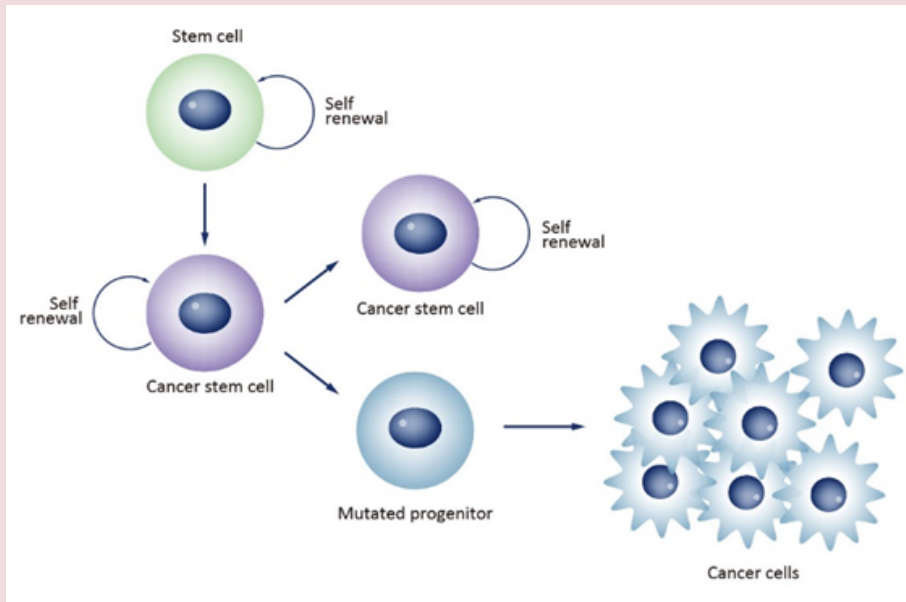


Figure 3: Cancer stem cells CSCs

**Classification of Cell Therapies:**

The following classifications are introduced for technologies that involve cells in various ways to treat diseases (figure 4) and a brief description of each technology is discussed in the following section.

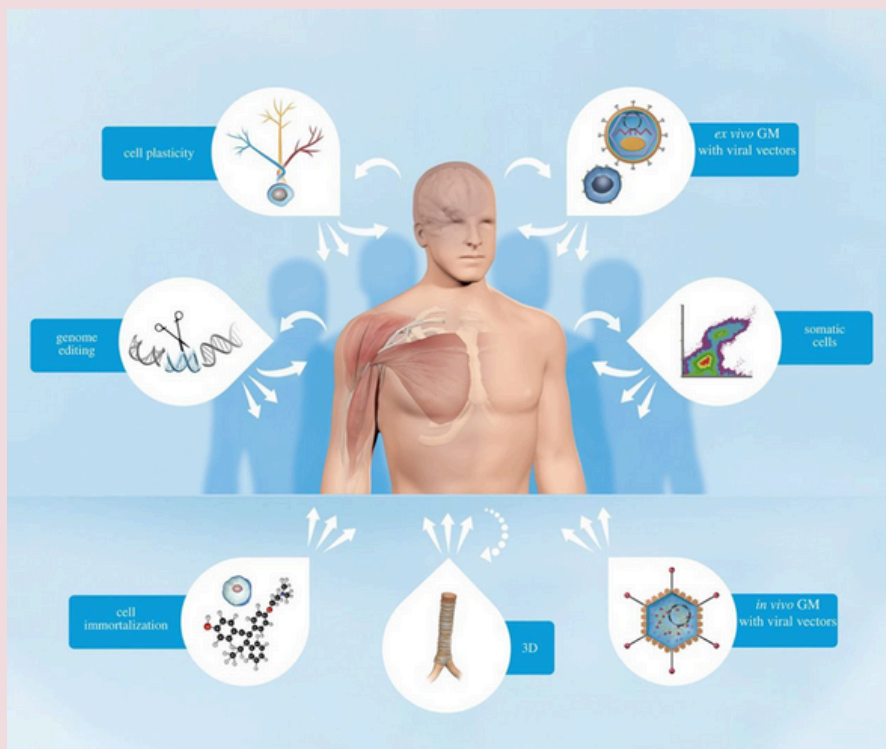


Figure 4: Classification of Cell Therapies

1. Somatic cell technologies
2. Cell immortalization technologies
3. Ex vivo gene modification of cells using viral vector technologies
4. In vivo gene modification of cells using viral vector technologies
5. Genome editing technologies
6. Cell plasticity technologies
7. Three-dimensional technologies

**1. Somatic cell technologies:** This technique employs human body cells that have been purified, multiplied, and/or differentiated into a particular cell product that is then supplied to a patient for a particular treatment without the need of any additional technology. Thus, despite the many cell types covered in this technology category, the translational obstacles are comparable from a technological standpoint. (Figure 5).4

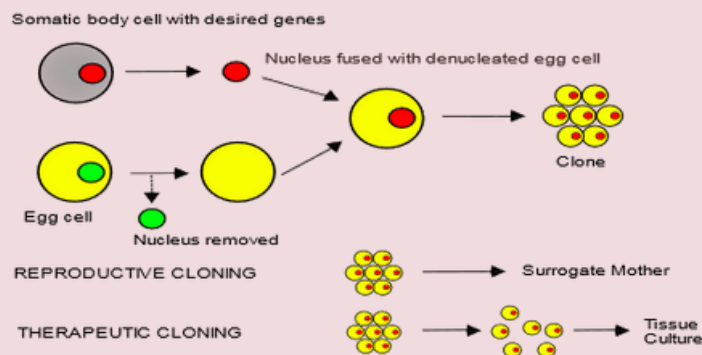


Figure 5: Somatic cell technologies

**2. Cell immortalization technologies:** The brain stem cell line CTX is the most well-known example of this technological field. CTX is a clonal cell line derived from foetal cortical brain tissue that has a single copy of the c-mycERTAM transgene that was spread by retroviral infection. (figure 6).5

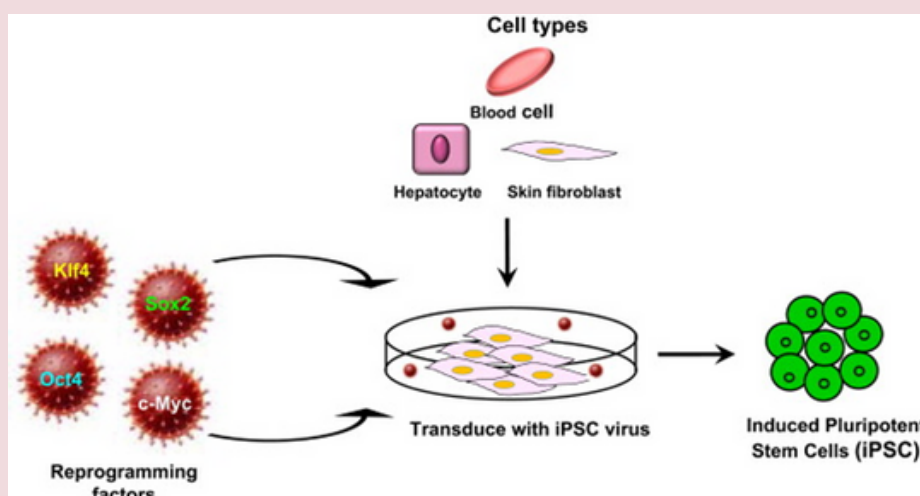


Figure 6: Cell immortalization technologies

**3. Ex vivo gene modification of cells using viral vector technologies:** T cells, HSCs, and MSCs are the most often employed cell types for ex vivo gene changes in cell therapy, with viral vector technology. Gene-modified MSCs are just beginning their first clinical studies for conditions like advanced cancer, whereas gene-modified HSCs have shown promise in the treatment of conditions like adenosine deaminase severe combined immunodeficiency disease (ADA- SCID). (Figure 7).6

**4. In vivo gene modification of cells using viral vector technologies:** Direct implantation of genetic material into a living organism is referred to as in vivo gene therapy. Although numerous delivery strategies are being developed, the most popular one involves modified viruses that contain targeted viral vectors and are infected in vivo to enter human cells shown in (Figure 7).7

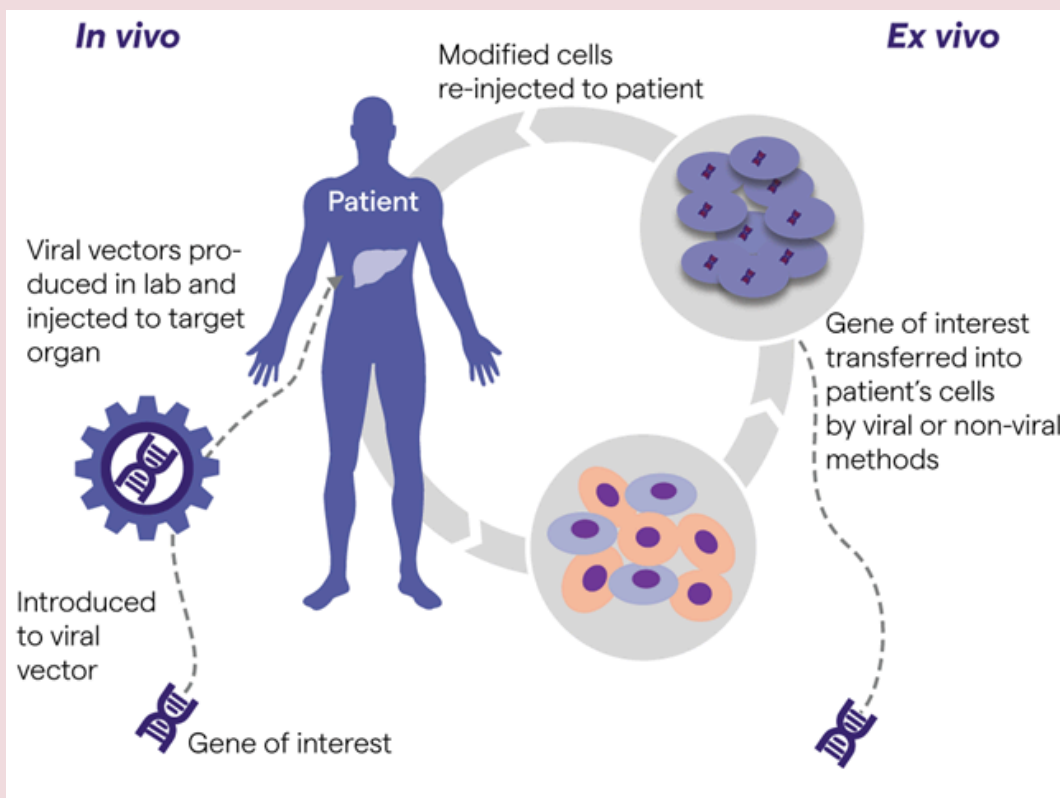


Figure 7: Ex vivo and in vivo gene modification of cells using viral vector technologies

**5. Genome editing technologies:** Genome editing, also known as gene editing, refers to a range of scientific techniques that enable the modification of an organism's DNA. At specific sites in the genome, these technologies enable the addition, removal, or modification of genetic material. Many diverse cell types and creatures have made substantial use of transcription activator-like effector nucleases (TALENs), zinc finger nucleases (ZFNs), and mega nucleases for genome editing. shown in (Figure 8).8

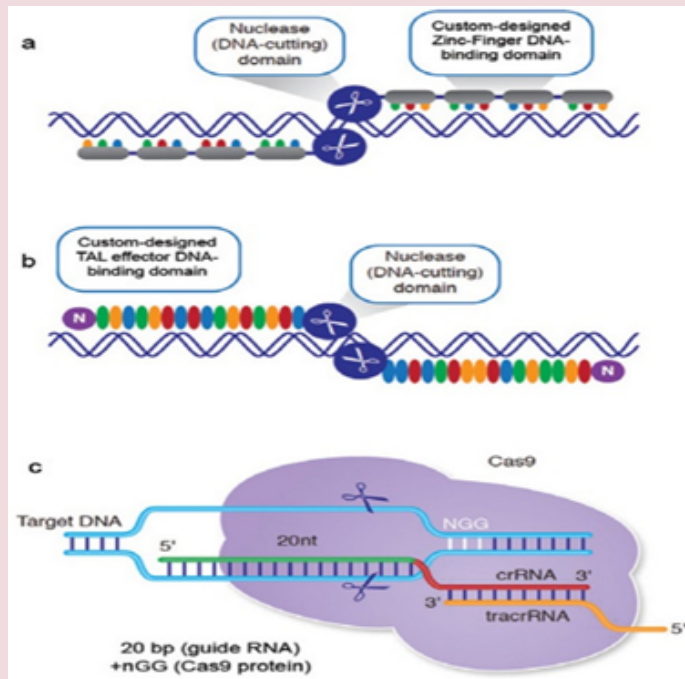


Figure 8: Genome editing technologies

**6. Cell plasticity technologies:** The capacity of a cell to reprogram and alter its phenotypic identity is referred to as cell plasticity, also known as lineage plasticity. Context-dependent cell plasticity takes place during embryonic development, tissue regeneration, and wound healing. (Figure 9).<sup>9</sup>

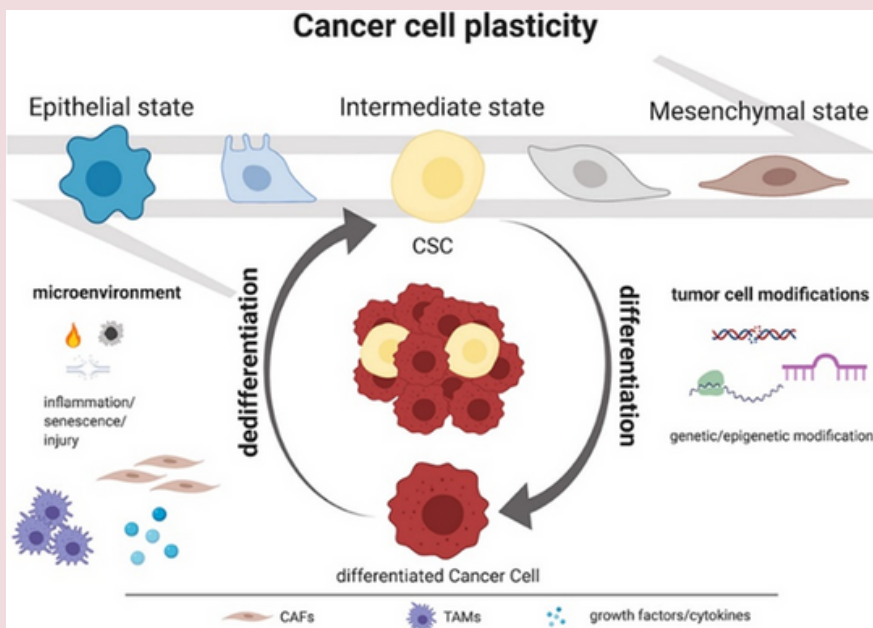


Figure 9: Cell plasticity technologies

**7. Three-dimensional technologies:** A 3D picture is a visual created by a computer that, when seen in computers, gives the impression of depth that an actual item would have. Movies, video games, visuals, and virtual reality (VR) initiatives like the metaverse frequently employ this technology.<sup>10</sup>

## **Clinical Benefit of Cell Therapy:**

### *1. Treatment of Cardiovascular Diseases*

Heart tissue can become oxygen-deprived from cardiovascular disorders, leading to the production of scar tissue that affects blood pressure or blood flow. According to study, the production of multiple growth factors enables adult bone marrow stem cells to differentiate into the cells needed to repair the heart and blood arteries.

### *2. Helps heal incisions and wounds*

According to studies, stem cell treatment can assist promote the formation of new, healthy skin tissue, boost collagen synthesis, encourage the growth of hair following cuts or hair loss, and help replace scar tissue with freshly formed, healthy tissue.

### *3. Treatment of Neurodegenerative Diseases*

Current advancements in the treatment of diseases like Parkinson's and Huntington's show that adult cells transplanted after brain traumas or cognitive degeneration can aid in the development of new brain neurons, cells, and synapses.

### *4. Autoimmune Diseases*

A new treatment option for those with severe and incapacitating autoimmune diseases including lupus and rheumatoid arthritis is stem cell therapy. When your immune system assaults your body's own tissues, cells, and organs, autoimmune illnesses develop. Stem cell treatment is a minimally invasive method used at ASAP that aims to minimise recovery time.

### *5. Orthopaedic Conditions*

This therapy can help those who are in pain due to orthopaedic disorders, spine illness, or sports injuries. ASAP addresses the fundamental causes of pain while also providing a chance for healing and long-term comfort.<sup>11</sup>

## **Conclusion:**

Cell therapy is a growing industry that includes stem cell- and non-stem cell-based unicellular and multicellular therapies. These treatments differ greatly in terms of their traits, sources of isolation, and applications. Another crucial element that has to be taken into consideration from the beginning of the development process is the potential future cost and reimbursement of new cell treatment. Overall, the quickening pace of science in this field and the emergence of cell-based medications that are revolutionizing patient care will continue to spur development, translation, and eventually commercialization.

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