ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11,S Iss 3, Dec 2022

PAST, PRESENT AND FUTURE OF STEM CELLS

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Abstract

Stem cell therapy has grown in popularity and complexity in recent years. Therapy has provided hope. This paper discusses stem cell discovery and treatment. Stem cells may be generated and altered in a lab. Teratoma formation and quality control assays help characterize stem cells. Use extraction and culture medium to optimize controlled differentiation. Graphene scaffolds and extracellular vesicle-based treatments may be applied in numerous stem tissue applications, therefore they need attention. The review summarizes stem cell treatment's challenges before global usage. This breakthrough therapy brings hope to the ailing.

Keywords: Stem cells, Differentiation, Pluripotency, Induced pluripotent stem cell (iPSC), Teratoma formation assay, Stem cell derivation, Growth media, Tissue banks, Tissue transplantation

Introduction

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Stem cells have been studied for more than a century [1], yet we still don't completely comprehend them. This review covers stem cell biology and therapeutic possibilities for interested parties. Stem cells can self-renew and develop into at least one adult cell. [2,3] Although the above core idea of "stemness" applies to stem cells generally, embryonic and adult stem cells differ in many ways.

Categorization of stem cells

Stem cells in humans don't do anything special. They can make themselves into any kind of cell. There are both adult and embryonic stem cells. There are many steps to becoming a specialist. At each step, a stem cell's ability to develop decreases, which limits the number of cells it can become.

Totipotent stem cells

Totipotent stem cells can split and turn into many different types of cells. Totipotency lets cells make structures both inside and outside of the embryo. Fertilization creates a totipotent cell called a zygote. These cells could turn into the placenta or one of the three germ layers. After 4 days, blastocyst cells can turn into any type of cell. This organelle makes cells that can become anything.

Pluripotent stem cells (PSCs)

PSCs make all germ layers except for tissues outside of the embryo, such as the placenta. Embryonic stem cells (ESCs). Preimplantation embryos create ESCs in their inner cell mass. iPSCs from implanted embryos' epiblast layers are another example. ESCs, iPSCs, multi-, oligo-, and unipotent cells are all pluripotent. Teratoma development tests their activity and spectrum. iPSCs are synthesized from somatic cells and behave like PSCs. Their cultivation and application offer considerable potential for regenerative medicine now and tomorrow.

Multipotent stem cells

Multipotent stem cells can specialise in some cell lineages, whereas PSCs can differentiate more. Haematopoietic stem cells may generate many blood cell types. HSCs become

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oligopotent. Only its lineage cells can differentiate. However, pluripotent cells may develop into unrelated cell types.

Oliogopotent and unipotent stem cells

Differentiating oligopotent stem cells creates several cell types. Myeloid stem cells can only make white blood cells. Unipotent stem cells may divide repeatedly and differentiate little. Because of this, they're useful for regenerative medicine therapy. These cells solely generate dermatocytes.

Stem cell biology

From sperm and an egg, a blastocyst grows. It is made up of embryonic stem cells. The trophectoderm and the inner cell mass (ICM) make up a blastocyst. The ICM turns into epiblasts and grows into a foetus (TE). Blastocysts regulate ICM microenvironment. The TE grows and makes structures outside of the embryo, like the placenta, that help the embryo develop. While the TE builds a framework for support, the ICM cells stay undifferentiated, pluripotent, and multiplying [4]. Stem cells can turn into any cell in the body because they are pluripotent. hESCs are made by the ICM. Endoderm, mesoderm, and ectoderm are the germ layers. Cells and tissues of the foetus and adult develop from the endoderm, mesoderm, and ectoderm. After becoming a germ layer, hESCs change into multipotent stem cells that only work in that germ layer.

Human development is short. Next, undifferentiated pluripotent stem cells are located throughout the body and may divide and differentiate into numerous cell types under specific physiological conditions. External and internal cues impact stem cell specialization. External signals include cell-cell interaction and tissue-secreted chemicals. Stem cells also mend the body. Cell renewal and growth are unconstrained in living organisms. Stem cells divide continually in bone marrow but only under particular physiological conditions in the pancreas [5].

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ISSN PRINT 2319 1775 Online 2320 7876

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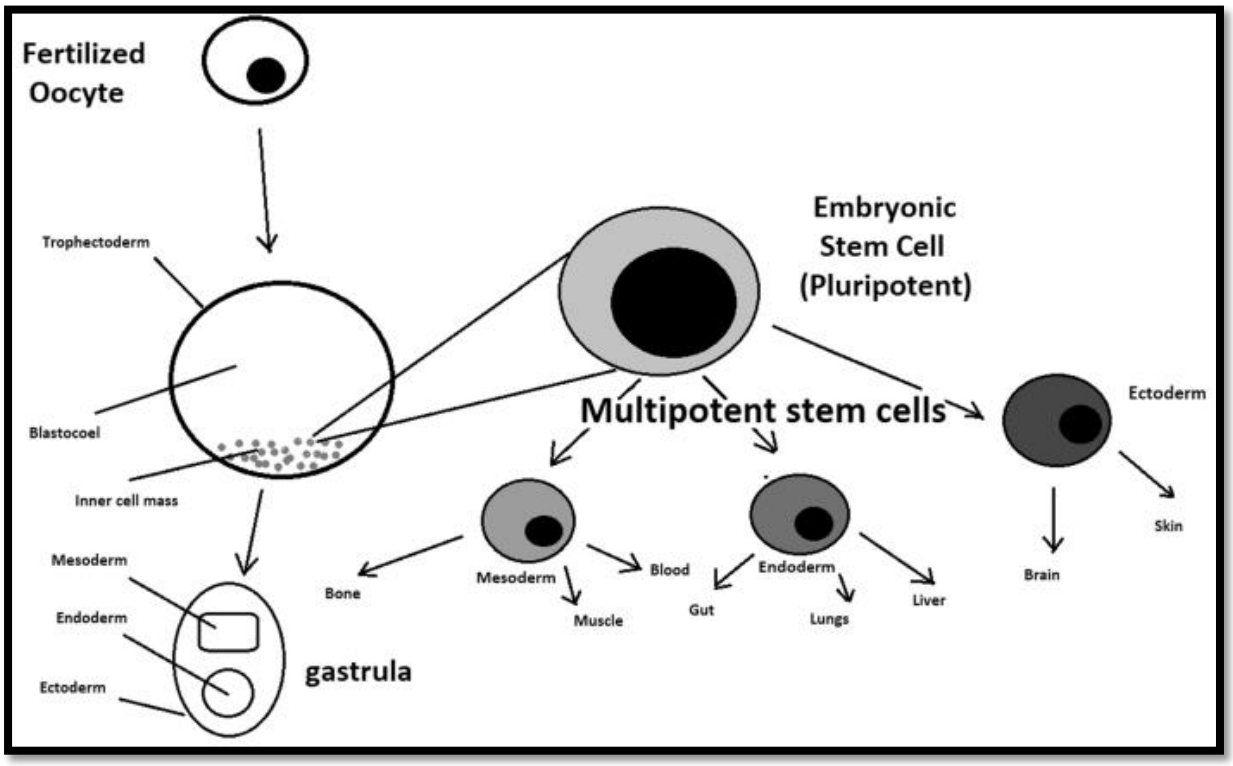

Figure:1 The growth of oocytes and stem cells: In the blastocoel, embryonic stem cells grow into cells that are mesodermal, ectodermal, or endodermal. These cells come from the oocyte. Blastocoel produces gastrula.

Embryonic Stem Cells

From the time they are placed in the uterus until the end of the second month of pregnancy, embryos are alive. Since blastocyst cells are taken out and grown in a lab 5 days after conception, "embryonic stem cells" (ESCs) don't live as long. [6]

ESC line setup

Fertilization produces a totipotent zygote. The morula, which is made up of 32–64 totipotent cells, is made when cells divide. It then turns into a blastocyst that is hollow. The placenta and embryonic membranes come from the trophoblast cells of the blastocyst, while the foetus grows from the inner cell mass. Stem cell cultures are made from these cells (Figure 2). Because totipotent cells can't make another embryo, pluripotent cells can make all types of

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adult cells. As the embryo grows, the three germ layers—the ectoderm, mesoderm, and endoderm—come together to form the gastrula, which is the starting point for the whole creature. In 1981, two groups made ESC lines from mouse blastocysts, and in 1998, the first ESC line from a human was made [7].The procedure seems simple, but it needs highly controlled settings to maintain cells undifferentiated. Human ESCs need this [8]. ESC lines may be relocated, frozen, and thawed. 250 human ESC lines are believed to exist, distributed throughout populations. Since scientific studies cannot tell if blastocysts are human, destroying them to create an ESC line raises moral problems. Isolating one cell from the inner cell mass to form ESCs allows the womb to implant the remaining cells. However, whether the surviving cells can grow into a regular person presents ethical concerns.

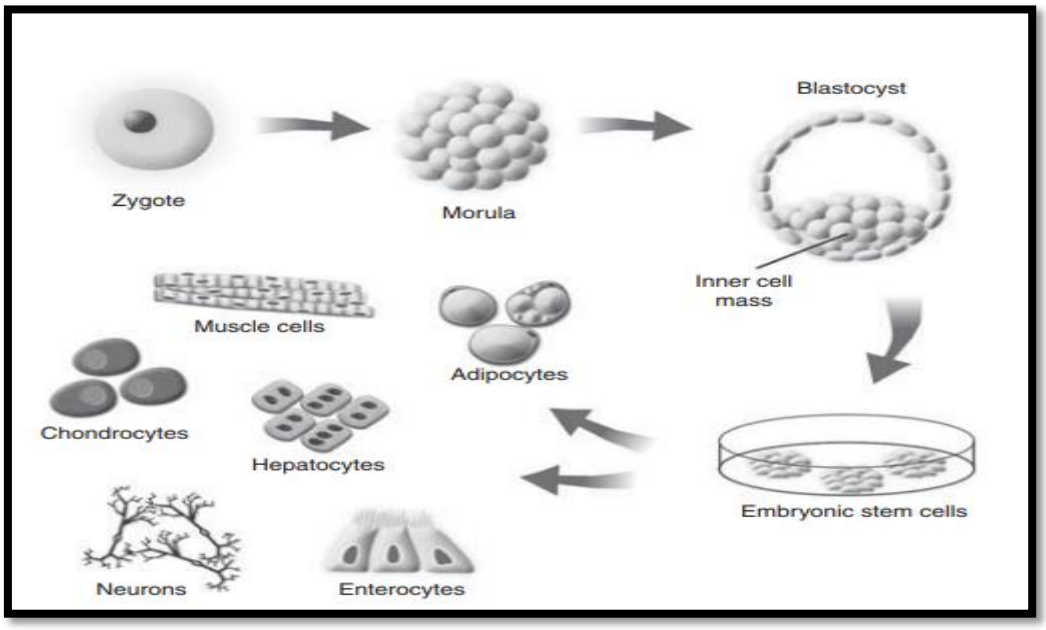

Figure: 2 Stem cells from embryos grow. The zygote divides over and over again to make the blastocyst. As the cell mass inside the blastocyst changes into the foetus, the trophoblast makes the placenta and embryonic membranes around it. Because a single pluripotent cell was taken from the inner cell mass, embryonic stem cells can live forever in a lab. These can turn into any kind of adult cell.

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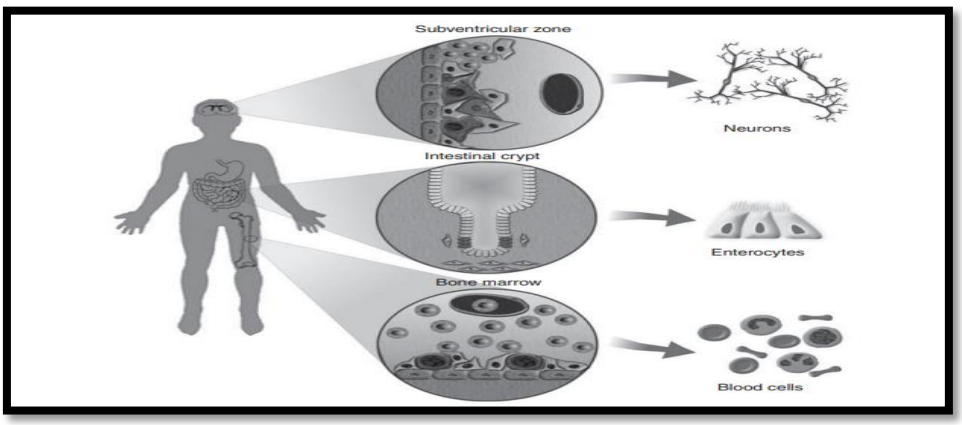
Adult Stem Cells

ASCs are rare, dormant cells that can only grow and change in certain ways. Different types of progenitor cells in adult tissues back up the idea that each tissue has its own stem cell compartment (Figure 3).

They replace damaged organ-specific cells. mature stem cells Hematopoietic, epithelial, muscular, and neural intrinsic stem cells are well known. [9] Cord blood and bone marrow transplants have utilised hematopoietic stem cells for almost 40 years. MSCs, which are stromal cells that can be taken out of almost any tissue, may live in the space around blood vessels. [10,11] MSCs are interesting for clinical use because they are easy to grow in the lab, can change into different types of tissues, provide trophic support, and control the immune system. [12] Even organs that have finished dividing, like the heart and kidneys, have stem cell compartments, though not much is known about what they do. [13,14]

Adult stem cells that are specific to a certain tissue are rare and don't have any surface markers or shapes that set them apart from mature cells. You can't separate them from any tissue. Stem cells and progenitor cells have been made more pure in different ways. Most human hematopoietic stem cells found in bone marrow or cord blood are positive for CD34 or CD133 and negative for CD38 and lineage. Hematopoietic stem cells can also be found in the "negative" cell marker population and the "enriched" fraction, which has different types of cells. Basic research at the ASC looks at molecular or biological parts. Animals are used in preclinical research on cell therapy. Patients with ASCs are helped by clinical research.



ISSN PRINT 2319 1775 Online 2320 7876

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Figure 3: Somatic stem cells (ASCs). ASCs are present in all organs and tissues and include neuronal, epithelial, and hematopoietic stem cells. They replace diseased or physiological cells (wear and tear).

Stem cell therapy turning point

Shinya Yamanaka and Kazutoshi Takahashi's discovery that multipotent adult stem cells might be converted to pluripotency revolutionised stem cell therapy. This approach protected the foetus. Retrovirus-mediated transduction of murine fibroblasts with embryonic stem cell transcription factors Oct-3/4, Sox2, KLF4, and c-Myc may make them pluripotent (Fig. 4) [15]. iPSCs are these unique stem cells. A year later, human cells worked [16]. After this, the approach opened a new stem cell research field by creating biocompatible, patient-specific iPSC lines. Recent research has focused on reducing carcinogenesis and improving conduction. 1962 and 1987 findings influenced the tipping point. First, scientist John Gurdon cloned frogs by introducing a frog's somatic cell nucleus into an egg, which reversed somatic cell development [17]. His study demonstrated that a somatic cell may regain pluripotency, which was surprising since cell differentiation was assumed to be one-way [18]. Davis R.L. discovered fibroblast DNA subtraction. Myoblasts produced three genes. Myogenic differentiation 1 (Myod1) was forced to be produced, converting fibroblasts into myoblasts, proving that reprogramming cells is possible and may even be used to shift cell lineages [19].

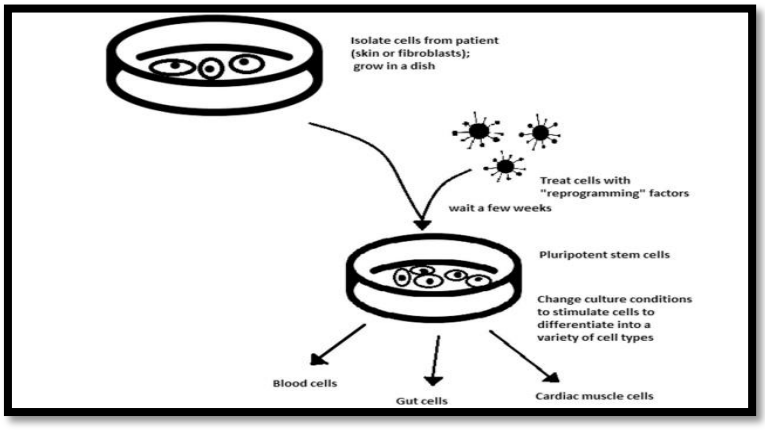

Fig: 4 Somatic cells of a patient become multipotent when they are infected with a retrovirus. Target cells go back to being pluripotent and can grow into any type of cell in the human body.

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Stem cell applications

Stem cell medicine

Medical stem cell use may increase. Their study advances restorative medicine and illuminates human development. DNA distinguishes stem cells from mature cells. The former cell contains functioning genes and loose DNA. As signals get into the cell and differentiation starts, genes that are no longer needed are turned off, but genes that are still needed for the new function stay on.

Interactions between gene sequences can both cause and stop pluripotency. Takahashi and Yamanaka [20] and Loh et al. [21] found that Oct3/4, SRY-box 2, and Nanog genes keep pluripotency. Oct3/4 and Sox2 are what iPSCs need. Many serious diseases, like cancer and birth defects, are caused by cells that don't divide or divide too slowly [22,23]. Stem cell treatments are used to treat torn tendons, type 1 diabetes, heart failure, degeneration of the retina and macula, and damage to the spinal cord [24]. Stem cell research can help improve how stem cells work. This could lead to new treatments for diseases that can't be cured.

Pharmacologically testing stem cells

Stem cells can be used to research new drugs and test them on living tissue. If a drug has side effects, the way it is made may be changed until it works. The drug may be sold without risking living testing. To properly test two pharmaceuticals, the circumstances must be same. Researchers must control differentiation to get pure cell populations.

Stem cell difficulties

Innovative scientific and medical breakthroughs must be closely watched to keep morality and safety in check. Stem cell therapy affects many parts of life, so it shouldn't be treated differently. Stem cells are having trouble. The first and most important step is to use animal models to figure out how stem cells work. You can't skip this step. Fear of the unknown is the biggest thing stopping the procedure from being used all over the world. If a normal patient is to trust stem cells, stem cell-directed differentiation needs to get better. The scope of a process is another issue. Possible future stem cell therapies could be hard. Stem cell therapy

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must make millions of working, physiologically correct cells that work together to make new organs that can be transplanted. To incorporate such difficult therapies into regenerative medicine, academia and international collaboration is needed. Identifying and isolating patient stem cells is another challenge. Immunological rejection prevents stem cell transplants. Certain stem cell types and therapies may cause the immune system to reject transplanted cells as alien things. A "failsafe" material might self-destruct if stem cells become hazardous. Stem cell adaptability and development may cut therapy costs for incurable diseases. Stem cell therapy might replace expensive drugs for organ failure. A successful operation would immediately benefit the patient and prevent long-term pharmacological treatment and associated side effects. Stem cell research is advancing despite these challenges. Stem cell therapy currently treats numerous diseases. They may shape future medical advances.

Conclusion

Stem cell therapy is transforming medicine after decades of study. Every experiment increases stem cell potential, yet several problems remain. Stem cells affect transplantology and regenerative medicine. Stem cell therapy may heal incurable neurological illnesses. Induced pluripotency enables patient cell usage. Tissue banks are famous because they gather cells for regenerative medicine to combat today's and tomorrow's diseases. Stem cell therapy and its regenerative powers allow us to prolong human life more than ever before.

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