

OVERVIEW ON: STEM CELL BOON FOR MANKIND

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ABSTRACT

Adult stem cells, also called tissue-specific stem cells or somatic stem cells, are multipotent cells, which are responsible for replacing damaged and dead cells in the body (tissue maintenance role). They are found in specific microenvironment called stem cell niche. Adult stem cells are often isolated from bone marrow, blood, adipose tissue, liver and skin. However, as a natural consequence of aging, their quantity and quality decreases with the age. Aging of stem cells affect regenerative potential, growth, and divisions. Stem cells are a current focus of intense scientific and clinical interest, particularly in the central nervous system (CNS) where inherent repair is inadequate and functional damage is often permanent. The prospective therapeutic power of stem cells lies in their ability to generate new cells of many types and to effect tissue repair. By definition, a stem cell is multipotent, with the capacity to self-renew.

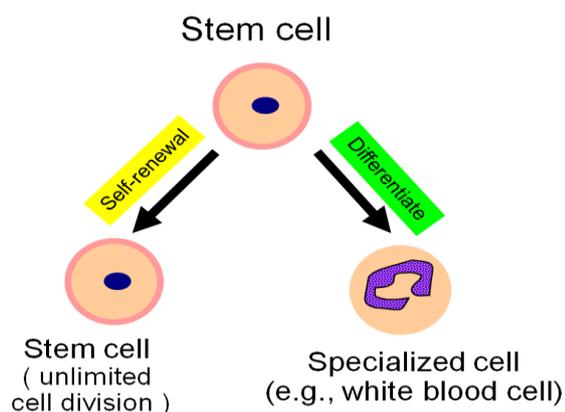
KEYWORDS: Stem cell, Multipotent, Bone Marrow, Adipose Tissue, Central Nervous System.

INTRODUCTION

STEM CELLS

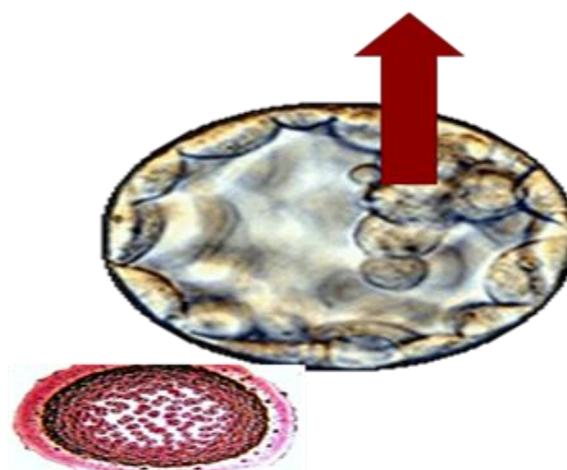
Stem cells are the foundation cells for every organ and tissue in our bodies. The highly specialized cells that make up these tissues originally came from an initial pool of stem cells formed shortly after fertilization. Throughout our lives, we continue to rely on stem cells to replace injured tissues and cells that are lost every day, such as those in our skin, hair, blood and the lining of our gut. Stem cells have two key properties:^[1]

- 1) The ability to self-renew, dividing in a way that makes copies of themselves, and
- 2) The ability to differentiate, giving rise to the mature types of cells that makes up our organs and tissues.^[1]



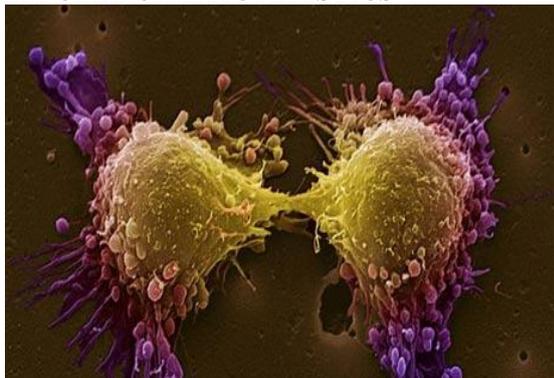
History of Human Embryonic Stem Cell Research

1. In 1998, James Thomson (University of Wisconsin-Madison) isolated cells from the inner cell mass of the early embryo, and developed the first human embryonic stem cell lines,



2. In 1998, John Gearhart (Johns Hopkins University) derived human embryonic germ cells from cells in fetal gonadal tissue (primordial germ cells).
3. Pluripotent stem cell "lines" were developed from both sources.^[3]

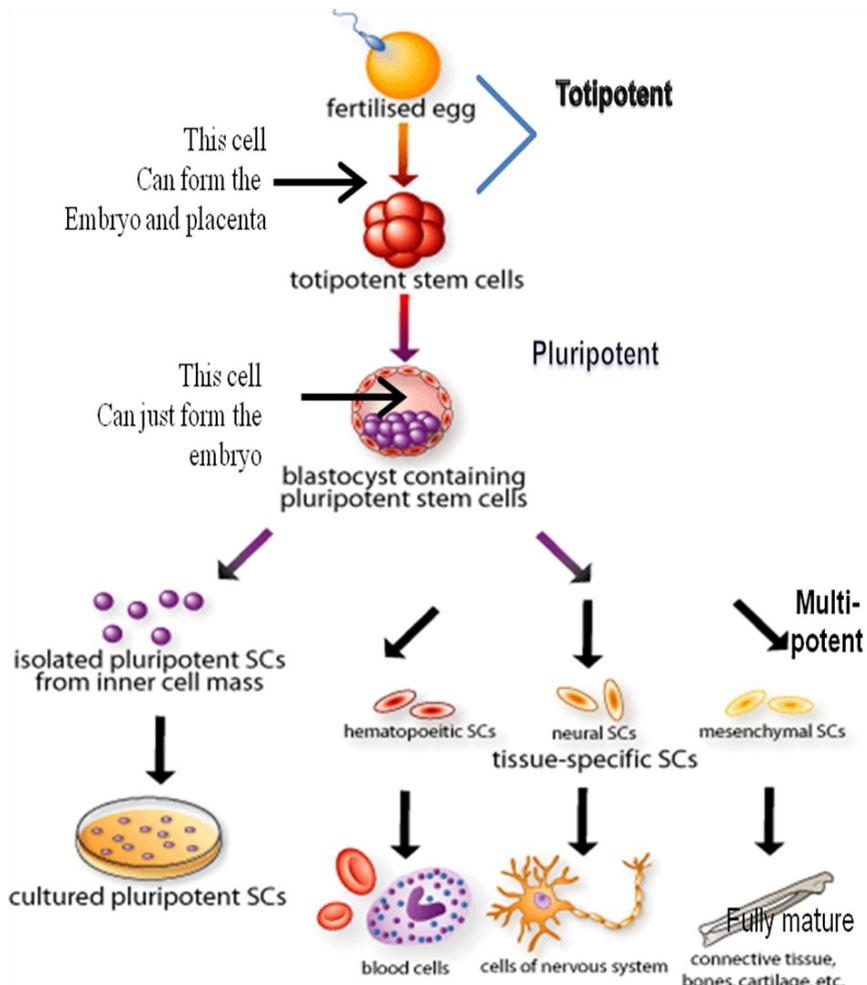
STEM CELL CHARACTERISTICS



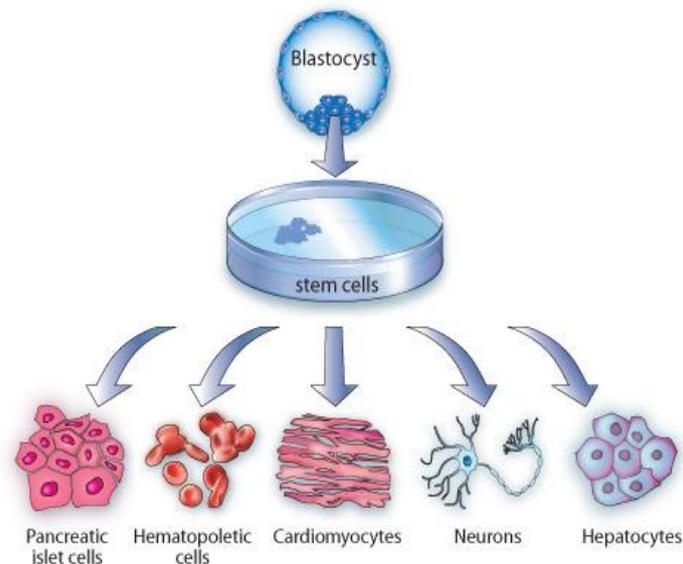
1. Blankcells' (unspecialized)
2. Capable of dividing and renewing themselves for long periods time (proliferation and renewal)
3. Have the potential to give rise to specialized cell types (differentiation).^[5]

KINDS OF STEM CELL

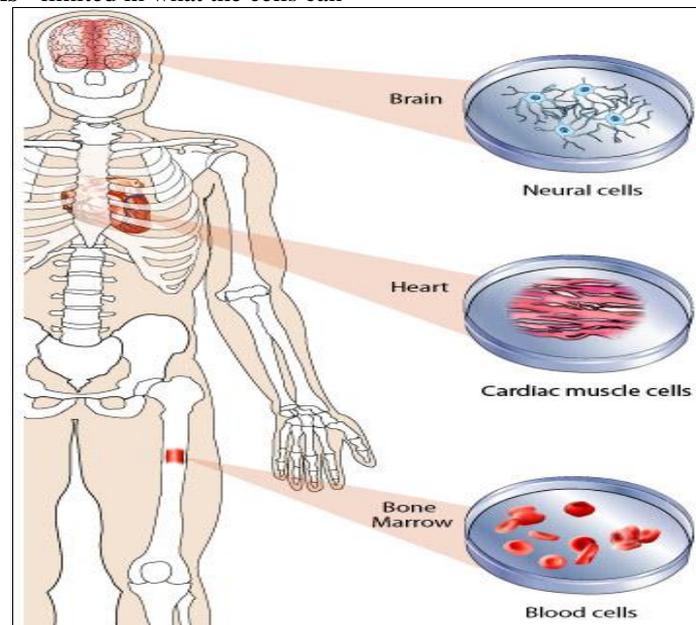
Stem cell type	Description	Examples
Totipotent	Each cell can develop into a new individual	Cells from early (1-3 days) embryos
Pluripotent	Cells can form any (over 200) cell types	Some cells of blastocyst (5 to 14 days)
Multipotent	Cells differentiated, but can form a number of other tissues	Fetal tissue, cord blood, and adult stem cells



- **Pluripotent Stem Cells** - more potential to become any type of cell



- **Multipotent stem cells** - limited in what the cells can



CLASSIFICATION OF STEM CELL

1. Embryonic stem cells

- Five to six-day-old embryo
- Tabula rasa
- Cells found early (less than 2 wks.) in the development of an embryo
- Embryonic stem cells are the most versatile because they can become any cell in the body including fetal stem cells and adult stem cells.
- Embryonic stem (ES) cells are taken from inside the blastocyst, a very early stage embryo. The blastocyst is a ball of about 50-100 cells and it is not yet implanted in the womb. It is made up of an outer layer of cells, a fluid-filled space and a group of cells called the inner cell mass. ES cells are found in the inner cell mass.

2. Embryonic germ cells

- Derived from the part of a human embryo or fetus that will ultimately produce eggs or sperm (gametes).

3. Adult stem cells

- Undifferentiated cells found among specialized or differentiated cells in a tissue or organ after birth
- Appear to have a more restricted ability to produce different cell types and to self-renew.
- Adult stem cells are found in the human body and in umbilical cord blood.
- The most well known source of adult stem cells in the body is bone marrow but they are also found in many organs and tissues; even in the blood.
- Adult stem cells are more specialized since they are assigned to a specific cell family such as blood cells, nerve cells, etc.

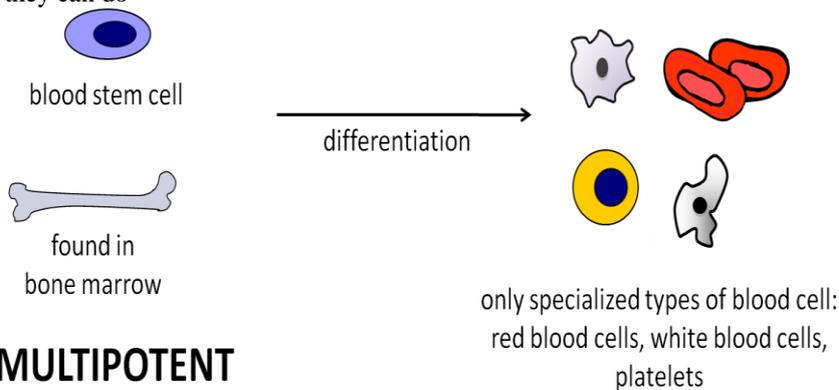
- Recently, it was discovered that an adult stem cell from one tissue may act as a stem cell for another tissue, i.e. blood to neural.^[6]



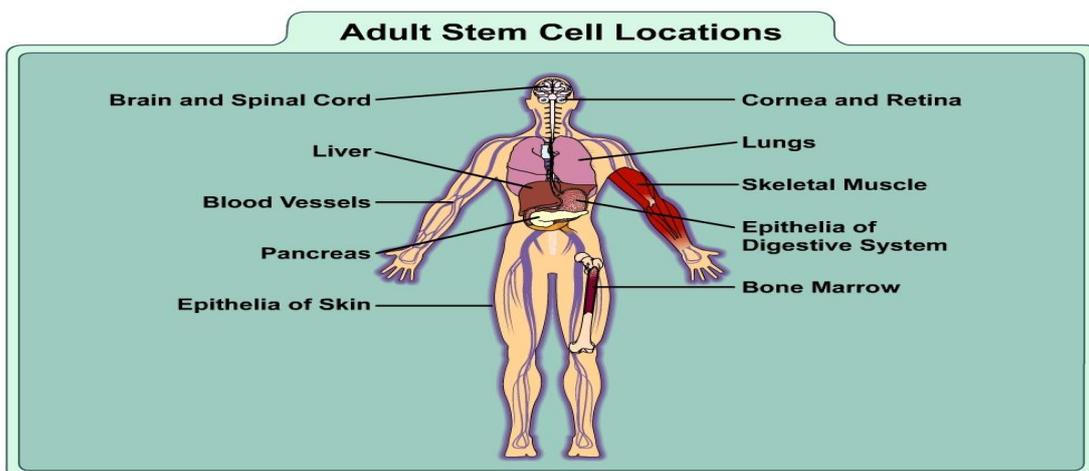
Sexual Reproduction



Adult stem cell: what they can do



MULTIPOTENT



8. SOURCE OF STEM CELL

- Stem cells may be derived from autologous, allogeneic or xenogenic sources. Histocompatibility is prerequisite for transplantation of allogeneic stem cells. Fetal tissue is the best current tissue source for human neural stem cells, however ethical issues are a major concern.^[7]

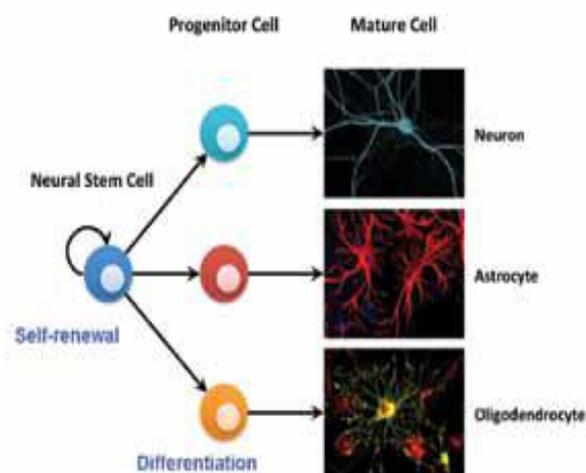
➤ **Placenta a Source of Stem Cells**



- Placental stem cells, like umbilical cord blood and bone marrow stem cells, can be used to cure chronic blood-related disorders such as sickle cell disease, Thalasemia, and leukaemia.

TISSUE-SPECIFIC STEM CELLS

Tissue-specific stem cells, which are sometimes referred to as “adult” or “somatic” stem cells, are already somewhat specialized and can produce some or all of the mature cell types found within the particular tissue or organ in which they reside. Because of their ability to generate multiple, organ-specific, cell types, they are described as “multipotent.” For example, stem cells found within the adult brain are capable of making neurons and two types of glial cells, astrocytes and oligodendrocytes. Tissue-specific stem cells have been found in several organs that need to continuously replenish themselves, such as the blood, skin and gut and have even been found in other, less regenerative, organs such as the brain. These types of stem cells represent a very small population and are often buried deep within a given tissue, making them difficult to identify, isolate and grow in a laboratory setting.^[8]

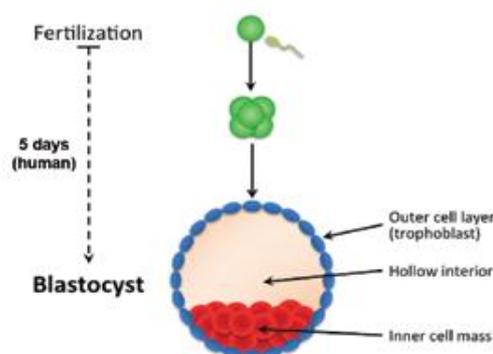


Neuron – Dr. Gerry Shaw, EnCor Biotechnology Inc.
Astrocyte – Abcam Inc. Oligodendrocyte – Dhaunchak and Nave (2007).

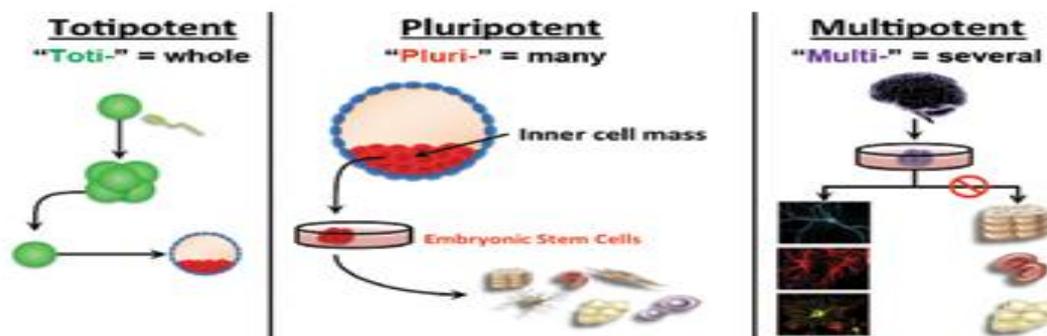
EMBRYONIC STEM CELLS

Embryonic stem cells are obtained from the inner cell mass of the blastocyst, a mainly hollow ball of cells that, in the human, forms three to five days after an egg cell is fertilized by a sperm. A human blastocyst is about the size of the dot above this “i.” In normal development, the cells inside the inner cell mass will give rise to the more specialized cells that give rise to the entire body—all of our tissues and organs. However, when scientists extract the inner cell mass and grow these cells in special laboratory conditions, they retain the properties of embryonic stem cells. Embryonic stem cells are pluripotent, meaning they can give rise to every cell type in the fully formed body, but not the placenta and umbilical cord.

Embryonic stem cells have been derived from a variety of species, including humans, and are described as “pluripotent,” meaning that they can generate all the different types of cells in the body. Embryonic stem cells can be obtained from the blastocyst, a very early stage of development that consists of a mostly hollow ball of approximately 150-200 cells and is barely visible to the naked eye. At this stage, there are no organs, not even blood, just an “inner cell mass” from which embryonic stem cells can be obtained. Human embryonic stem cells are derived primarily from blastocysts that were created by in vitro fertilization reproduction but were no longer needed.



The fertilized egg and the cells that immediately arise in the first few divisions are “totipotent.” This means that, under the right conditions, they can generate a viable embryo (including support tissues such as the placenta). Within a matter of days, however, these cells transition to become pluripotent. None of the currently studied embryonic stem cell lines are alone capable of generating a viable embryo (i.e., they are pluripotent, not totipotent).^[9]



EMBRYONIC STEM CELLS SO VALUABLE

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CURRENT THERAPIES

Blood stem cells are currently the most frequently used stem cells for therapy. For more than 50 years, doctors have been using bone marrow transplants to transfer blood stem cells to patients, and more advanced techniques for collecting blood stem cells are now being used to treat leukemia, lymphoma and several inherited blood disorders. Umbilical cord blood, like bone marrow, is often collected as a source of blood stem cells and in certain cases is being used as an alternative to bone marrow transplantation. Additionally, some bone, skin and corneal diseases or injuries can be treated by grafting tissues that are derived from or maintained by stem cells. These therapies have also been shown to be safe and effective.^[11]

POTENTIAL THERAPIES

Other stem cell treatments, while promising, are still at very early experimental stages. For example, the mesenchymal stem cell, found throughout the body including in the bone marrow, can be directed to become bone, cartilage, fat and possibly even muscle. In certain experimental models, these cells also have some ability to modify immune functions. These abilities have created considerable interest in developing ways of using mesenchymal stem cells to treat a range of musculoskeletal abnormalities, cardiac disease and some

immune abnormalities such as graft-versus-host disease following bone marrow transplant.^[12]

REMAINING CHALLENGES

Despite the successes we have seen so far, there are several major challenges that must be addressed before stem cells can be used as cell therapies to treat a wider range of diseases.

1. First, we need to identify an abundant source of stem cells. Identifying, isolating and growing the right kind of stem cell, particularly in the case of rare adult stem cells, are painstaking and difficult processes. Pluripotent stem cells, such as embryonic stem cells, can be grown indefinitely in the lab and have the advantage of having the potential to become any cell in the body, but these processes are again very complex and must be tightly controlled. iPS cells, while promising, are also limited by these concerns. In both cases, considerable work remains to be done to ensure that these cells can be isolated and used safely and routinely.
2. Second, as with organ transplants, it is very important to have a close match between the donor tissue and the recipient; the more closely the tissue matches the recipient, the lower the risk of rejection. Being able to avoid the life-long use of immune suppressants would also be preferable. The discovery of these cells has opened the door to developing patient-specific pluripotent stem cell lines that can later be developed into a needed cell type without the problems of rejection and immunosuppression that occur from transplants from unrelated donors.
3. Third, a system for delivering the cells to the right part of the body must be developed. Once in the right location, the new cells must then be encouraged to integrate and function together with the body's other cells.^[13]

APPLICATION OF STEM CELLS

- Disease
 - Diabetes, Spinal cord injury, Parkinson's disease, heart disease
- Genetic based Disease
 - Cystic fibrosis, Huntington's
- Cell Replacement Therapies

- Cells could be stimulated to develop into specialized cells that represent renewable sources of cells and tissue for transplantation.
- Cell replacement therapy could treat injuries and various genetic and degenerative conditions including muscular dystrophies, retinal degeneration, Alzheimer disease, Parkinson's disease, arthritis, diabetes, spinal cord injuries, and blood disorders such as hemophilia.^[15]
- Stability of stem cells 18-25 years
- Some feel that the use of iPS cells to model human diseases will be the technology that is available first.^[19] This would allow treatments and drugs to be tested for their effect on diseased human cells and whether or not they are toxic to the cells. Some early experiments have already been carried out that demonstrate this potential.^[20]

RESEARCH LABORATORIES

- Institute of stem cell research and regenerative medicine, Bangalore
- National Centre for Biological Sciences (NCBS), Bangalore
- Jawaharlal Nehru Centre for Advance Scientific Research (JNCASR), Bangalore
- National Centre for Cell Sciences (NCCS), Pune
- National Brain Research Centre(NBRC), Manesar
- Centre for Cellular and Molecular Biology (CCMB), Hyderabad
- Central Leather Research Institute (CLRI),Chennai
- Institute of Immunohematology, Mumbai
- **Hospitals**
- All India Institutes of Medical Sciences (AIIMS), New Delhi
- Sir Ganga Ram Hospital, New Delhi
- Sankara Nethrayalya, an eye hospital, Chennai
- Christian Medical College and Hospitals
- LV Prasad Eye Institute (LVPEI), Hyderabad

Academic Institutions

- Special Centre for Molecular Medicine, Jawaharlal Nehru University (JNU) New Delhi
- Guru Go bind Singh Indraprastha University, New Delhi
- University of Delhi
- Acharya Nagarjuna University, Guntur
- Sri Ramachandra University, Chennai
- Indian Institute of Science (IISc), Bangalore

Kasturba Medical College, Manipal

CONCLUSION

The vast possibilities of what stem cell research could achieve mean that the expectations for this research from both the public and scientific community are huge. However, whilst there are some clinical trials with stem cell therapies in the UK, few stem cell treatments are currently commonplace in UK hospitals. It would be misleading for this publication to suggest that stem cell therapies from iPS cells will be available soon in UK hospitals. Most scientists would acknowledge that much work is needed to investigate the characteristics, control, safety and reliability of iPS cells. In particular, what the similarities and differences are between iPS cells and ES cells. These issues must be considered before the research can be turned into medical treatments.

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