Stem Cell Definition, Classification and Research History

Ma Hongbao *, Yang Yang *, Margaret Ma **

* Brookdale Hospital, Brooklyn, New York 11212, USA, ma8080@gmail.com
** Boston, Massachusetts 02138, USA

Abstract: This article gives a brief description of the Stem Cell Definition, Classification and Research History.
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1. Definition of Stem Cells

The definition of stem cell is "an unspecialized cell that gives rise to a specific specialized cell, such as a blood cell" (Stedman's Medical Dictionary, 2002).

2. Stem Cell Classification:

Different types of stem cells vary in their degree of plasticity, or developmental versatility. Stem cells are perhaps best understood in terms of how committed they are to becoming any particular type of cell. The categories into which they fall include: the totipotent stem cell, pluripotent stem cell, multipotent stem cell, and the adult stem cell. Stem cells can also be classified according to their plasticity..

(1) Totipotent Stem Cells

These are the most versatile of the stem cell types. When a sperm cell and an egg cell unite, they form a one-celled fertilized egg. This cell is totipotent, meaning it has the potential to give rise to any and all human cells, such as iver, kidney, brain, blood, skin or heart cells, etc. The first few cell divisions in embryonic development produce more totipotent cells. After four days of embryonic cell division, the cells begin to specialize into pluripotent stem cells.

(2) Pluripotent Stem Cells

These cells are like totipotent stem cells in that they can give rise to all tissue types. Unlike totipotent stem cells, however, they cannot give rise to an entire organism. On the fourth day of development, the embryo forms into two layers, an an outer layer which will become the placenta, and an inner mass which will form the tissues of the developing human body. These inner cells, though they can form nearly any human tissue, cannot do so without the outer layer; so are not totipotent, but pluripotent. As these pluripotent stem cells continue to divide, they begin to specialize further.

(3) Multipotent Stem Cells

These are less plastic and more differentiated stem cells. They give rise to a limited range of cells within a tissue type. The offspring of the pluripotent cells become the progenitors of such cell lines as blood cells, skin cells and nerve cells. At this stage, they are multipotent. They can become one of several types of cells within a given organ. For example, multipotent blood stem cells can develop into red blood cells, white blood cells or platelets.

(4) Adult Stem Cells

An adult stem cell is a multipotent stem cell in adult humans that is used to replace cells that have died or lost function. It is an undifferentiated cell present in differentiated tissue. It renews itself and can specialize to yield all cell types present in the tissue from which it originated. So far, adult stem cells have been identified for many different tissue types such as hematopoetic (blood), neural, endothelial, muscle, mesenchymal, gastrointestinal, and epidermal cells

3. Stem Cell Types

(1) There is More than One Source for Stem Cells

Stem cells are often classified with regard to their origin. Stem cells are present both in the embryo and in the adult. Depending on where the stem cells originate, they have different properties. According to this classification scheme, the three kinds of stem cells are: Embryonic stem cells, embryonic germ cells, and adult stem cells.

(2) Embryonic stem cells

From the inner cell mass, which is part of the early (4-5 day old) embryo called the blastocyst. Once removed, the cells of the inner cell mass can be cultured into embryonic stem cells.

(2) Embryonic germ cells

Having characteristics similar to embryonic stem cells. Embryonic germ cells, however, are collected from the fetus later in the developmental process from a region known as the gonadal ridge (which would eventually develop into the sex organs). Though these cells can give rise to the three germ layers that make all the specific organs of the body, the cell types that can develop from embryonic germ cells are slightly more limited than those that develop from embryonic stem cells. This is because embryonic

germ cells are further along in the developmental process.

(3) Adult stem cells

Originate from mature adults. These can also be referred to as multipotent stem cells, as the number of cell types which they can differentiate into are limited. Adult stem cells serve as a fresh source of cells in living organisms. They replace cells that need to be replaced on a regular basis in a living organism, such as blood (which has a 120 day lifespan) and other connective tissues. It is generally believed that adult stem cell therapies will complement but not replace embryonic stem cell therapies. One advantage of adult stem cells is that they offer the opportunity to utilize small samples of adult tissues of a patient's own cells for expansion and subsequent implantation. This avoids the ethical issues of embryonic stem cells, as well as the issues that accompany allogeneic donations.

(4) type of stem cell

No one type of stem cell is necessarily better than the other, rather the different stem cells have different advantages.

4. History of Stem Cells Research

- 1878-The first attempts were made to fertilize mammalian eggs outside the body
- 1959-First animals made by in-vitro fertilization (IVF)
- 1960s-Teratocarcinomas determined to originate from embryonic germ cells in mice. Embryonal carcoinoma cells (EC) identified as a kind of stem cell.
- 1968-The first human egg is fertilized in vitro
- 1970s- EC cells injected into mouse blastocysts make chimeric mice. Cultured SC cells are explored as models of embryonic development in mice.
- 1978-the first IVF baby is born in England
- 1981-Mouse ES cells are derived from the inner cell mass of blastocysts. Mouse ES cells are grown in vitro. ES cells injected into mice form teratomas.
- 1984-88-Pluripotent, clonal cells called embryonal carcinoma (EC) cells are developed. When exposed to retinoic acid these cells differentiate into neuron-like cells and other cell types.
- 1989-A clonal line of human embryonal carcinoma cells is derived that yields tissues from all three primary germ layers. They have limited replicative and differentiative capacity.
- 1994-Human blastocysts are generated and the inner cell mass is maintained in culture. ES like cells form in the center and retain stem cell like morphology.
- 1995-96-Non-human primate ES cells are maintained in vitro from the inner cell mass of monkeys. These cells are pluripotent and differentiate normally into all three primary germ layers
- 1998-ES cells from the inner cell mass of normal human blastocysts are cultured and maintained normally for many passages. EG cells are also derived and grown in vivo.
- 2000-Scientists derive human ES cells from the inner cell mass of blastocysts. They proliferate in vitro for a long time and form all three germ layers and teratomas when injected into immune deficient mice.
- 2001-As human ES cell lines are shared and new lines are derived, more research groups are focusing attention on the differentiation of cells in vitro. Many methods focus on making human tissues for transplantation.

5. Characterization of Stem Cell

Stem cell is totipotent, that means it holds all the genetic information of the living body and it can develop into a mature cell. Stem cell is a single cell that can give rise to progeny that differentiate into any of the specialized cells of embryonic or adult tissue. The ultimate stem cells (fertilized egg) divide to branches of cells that form various differentiated tissues or organs. During these early decisions, each progeny cell retains totipotency. Through divisions and differentiations the embryonic stem cells lose totipotency and gain differentiated function. During normal tissue renewal in adult organs, tissue stem cells give rise to progeny that differentiate into mature functioning cells of that tissue. Stem cells losing totipotentiality are progenitor cells. Except for germinal cells, which retain totipotency, most stem cells in adult tissues have reduced potential to produce different cells.

6. Sources of Stem Cells

Aristotle (384-322 BC) deduced that the embryo was derived from mother's menstrual blood, which was based on the concept that living animals arose from slime or decaying matter. This concept was accepted in western world for over 2000 years, and it controlled western philosophy for over 2000 years either. In 1855, Virchow supposed that all cells in an organism are derived from preexisting cells. Now we know that all the human cells arise from a preexisting

stem cell – the fertilized egg, that come from the mating of a man and a woman naturally but now can be produced in the laboratory tube. The counter hypothesis of spontaneous generation was accepted until 1864, when the French scientist Louis Pasteur demonstrated that there would be no microorganisms' growing after sterilizing and sealing.

The animal body has an unlimited source of stem cells, almost. However, the problem is not in locating these stem cells, but in isolating them from their tissue source.

Five key stem cells have been isolated from human: (1) Blastocysts; (2) Early embryos; (3) Fetal tissue; (4) Mature tissue; (5) Mature cells that can be grown into stem cells.

Up to today, only stem cells taken from adults or children (known generically as "adult stem cells") have been used extensively and effectively in the treatment of degenerative diseases.

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