Chapter 10

Stem Cells: Biological “Jack-of-All-Trades”

**Section 1: What are Stem Cells?**

Stem Cell: An unspecialized cell characterized by self-renewal and the ability to differentiate into another cell.

You may be familiar with the term “stem cell” by watching or reading the news. This is because stem cells are a fairly new subject in both the clinical and scientific research settings. But, what are stem cells and what makes them relevant in a society that has so much to direct it’s attention towards. A creative way of viewing stem cells is, as the title suggests, a biological “jack-of-all-trades”. We will discuss what this means in a more scientific manner throughout the chapter; for now think of stem cells like this: Stem cells are common cells that are produced by the human body, these cells have the ability to perform the functions of other cells (skin, liver, cardiac, etc.) even though they do not start out as that particular cells.

A concept that needs to be understood before delving into stem cells is that of cellular differentiation. Cell differentiation is the manner in which cell functions and physical properties, and therefore cell type is determined. For example a skin cell is a skin cell, a brain cell is a neuro cell, and a kidney cell is a kidney cell. While there is more to learn, focus on this idea to aid in comprehending stem cells: each of these cells complete a specific function from its origin to its death, a skin cell can not function as a neuro cell nor can a neuro cell function as a kidney cell, these cells are differentiated. Also note that the cells divide into similarly differentiated cells of the same type.

Differentiation: The degree to which a cell is specialized

Contrary to skin cells, neuro cells, kidney cells, etc. stem cells are undifferentiated. This characteristic is what makes them what they are and brings about their importance. Because stem cells are undifferentiated they have the special ability to do two very key things for us in the clinical setting. 1) These cells are capable of self-renewal. Meaning that one stem cell (undifferentiated) can produce an additional stem cell that is also undifferentiated (A caveat to undifferentiated cells will be discussed later in the chapter). This means that, under the proper conditions stem cells will continue to produce additional undifferentiated cells. 2) Stem cells also have the ability to differentiate into various cell lineages or types of cells. In other words stem cells have the capacity to become skin, neuro, and kidney cells; other cells do not have this ability but are rather stuck as whatever cell they happen to be.

Cell Lineage: The ancestry of the cell starting at the embryo.

**Section 2: Where can stem cells be found?**

The question of where stem cells can be found is one of importance. Where the stem cell is found determines its level of differentiation. The level of differentiation is known as potency. As discussed in section 1 stem cells are undifferentiated, but the level to which they are undifferentiated can vary. All stem cells have the ability to self-renew and further differentiate into one of several cell types. However, some stem cells have the ability to differentiate into any, or one of all, of the types of cells that make up the human body, while some are limited to only dividing into cells that fall under the same germ layer as that stem cell’s origin.

Germ layer: Three layers of cells that are formed in the embryos early stages. All human cells are developed from these germ layers

A stem cells potency is described by a prefix + “potency” e.g.: pluripotent. The prefix “pluri” means many or several; therefore pluripotent stem cells have the ability to form several cell types. Other stem cells types include: Totipotent, Multipotent, Oligopotent, and Omnipotent. These cell are ordered by level of differentiation from least differentiated to most differentiated as follows:

* **Totipotent**: These stem cells have the ability to form any embryonic cell or extra embryonic cell. They are only slightly more differentiated than a fertilized egg.
* **Pluripotent**: These cells have the potential to differentiate into any of the cells under the three germ layers (They can make any cell inside the adult human body).
* **Multipotent:** These cells can differentiate only into closely related cells (For example: a multipotent stem cell found in bone marrow can differentiate only into any of the types of blood cells, but not a neuro cell; \*\*\*some BMSC can be differentiated into neuro cells.)
* **Oligopotent:** These cells can only form a few different cells
* **Omnipotent**: These cells can only form one particular cell type but have the ability of self-renewal.

The Totipotent stem cells as well as the pluripotent stem cells come from embryos and are therefore referred to and characterized as embryonic stem cells (ES cells). Totipotent ES cells come from the embryo at it’s very early stage. Pluripotent ES cells also come from the embryo at a later stage. Embryonic stem cells are more useful due to their lower level of differentiation, however they are more difficult to obtain and some political and ethical controversies regarding the collection and use of these cells remain.

Embryo: Unborn off-spring between two to eight weeks post fertilization

The second broad category of stem cells are adult stem cells. These stem cells are both easier to obtain and are, generally speaking, exempt from the political and ethical controversies that are applied to embryonic stem cells. Adult stem cells are primarily multipotent, oligopotent, and omnipotent with rare occurrences of pluripotency. These stem cells come from developed tissues inside the human body. Bone marrow along with central nervous tissue, retina tissue, and tooth pulp, adipose tissue, and skin tissue are sources of adult stem cells.

**Section 3: Who can benefit from stem cells?**

Stem cells have the potential to be used as a tool in the clinical setting; they can be used to treat medical conditions in a more proficient way than the next best option that is currently available in medical fieldk. Their uses are broad, and in consideration of modern research, fairly untapped. As mentioned before there are political and ethical controversies that pertain to the usage and research of stem cell research. This slows the process of using and learning all that stem cells can be used for (these barriers will be discussed later.). As for now, stem cells are being used primarily for regeneration of tissue that is naturally slow at healing. These slowly regenerating tissues include cartilage, tendons, spinal and nervous system tissue, and cardiac tissue.

Those suffering from spinal cord injury have a condition that has or can lead to sever neurological damage. Neuro tissue is one of the many types of tissue that is slow, at best, to regenerate. This makes this subset of patients ideal candidates for these procedures that involve the use of stem cells. An example of lab research involves the regeneration of axonal functionality using Bone marrow stem cells to heal the spinal cords of animals. In clinical studies five patients benefited from stem cell research, who were previously suffering from acute spinal cord injury. These patients were injected with bone marrow stem cells. The patients under this study saw improved sensory and motor functions as a result of the stem cell therapy they received.

Several more clinical trials involving stem cells exist. As mentioned previously cartilage is slow to heal after it has been damaged. Damaged cartilage can lead to a pesky condition called arthritis which causes pain in joints. Clinical trial exist that have used bone marrow stem cells to aid in the healing process of damaged cartilage through an invasive surgery. These trials reported improvements, with inconsistency, of the patients’ functionality.

**Conclusion**

Several types of stem cells exist. Among all of these types two characteristics are constant: The ability to self-renew and the characteristic of undifferentiating/the ability of differentiation. These characteristics are what make stem cells viable candidates for several medical procedures of conditions that do not have preexisting effective procedures. Stem cells have the potential to serve may clinical purpose with additional research.

References

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