NASCIC
SCI RESEARCH
ADVOCACY COURSE

Module 8 – Cell Replacement

Introduction to Stem Cells, Cell Differentiation, and Cell Growth

To begin, we will discuss what stem cells are as well as why they are important. All the cells in the human body originate from stem cells that are formed during early development in utero.

There are two types of naturally occurring human stem cells used for research purposes, specifically being embryonic stem cells (ESCs) and adult stem cells (ASC).

ESCs are found only in embryos during the earliest stages of human development and have the ability to make all other types of cells in the body. The ability to turn into any other cell is termed "pluripotent".

ASCs remain in the body throughout our lives. Adult stem cells are found in a tissue or organ and can differentiate to yield the specialized cell types of that tissue or organ. Thus, they have less "potency" than ESCs, which mean they cannot make as many different cell types compared to ESCs. For example, mesenchymal stem cells can differentiate into bone, cartilage, muscle and fat cells, while hematopoietic stem cells can differentiate into all type of blood cells. In regards to SCI, neural stem cells can differentiate into neurons and glia that make up the brain and spinal cord.

Stem cells can multiply indefinitely and create new cell types when exposed to specific signals in the body in a process called "cell differentiation." Once cells have differentiated they have committed to a final cell type.

We can visualize the process of differentiation like a family tree. For example, neurons and glial cells come from the same family tree, or "lineage**."**

- Embryonic stem cells (ESCs) first differentiate into neural stem cells. Neural stem cells can still self-renew and differentiate without limit, but they have lost the ability to differentiate into any type of cell other than neurons, astrocytes, or oligodendrocytes.
- Neural stem cells then differentiate into "neural or glial progenitor cells" which have a limited ability to self-renew and are now committed to differentiate into either neurons or glial cells.
- Neural progenitor cells further differentiate into even more committed progenitor cells, which eventually differentiate into specific types of neurons or glial cells. Once a neuron has matured it no longer has the ability to self-renew or divide.

Human Neural Stem cells can be grown in laboratory, known as "cell culture". In the lab, skin cells, which are differentiated and committed to a non-neural lineage, can be reprogrammed back into a pluripotent state. This reprogramming occurs by exposing a differentiated cell to proteins (called Yamanaka factors) that are produced in embryonic stem cells and maintain their pluripotency. At the end of this process, the cells that were once differentiated have now become pluripotent and have similar properties to an embryonic stem cell – thus forming induced pluripotent stem cells (iPSCs). As long as these cells remain in culture under appropriate conditions, they can remain undifferentiated, but have the ability to make an almost unlimited amount of any cell in the body including neurons.

Given their unique regenerative abilities, the application of stem cells could be beneficial to SCI by developing therapeutic benefits to restore function.