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Stem Cells 101

By Hans R. Larsen MSC ChE

Stem cells are unique in that they are capable of dividing and renewing themselves for long periods. They are not specialized as to their function, but can be changed into cells with specific functions (differentiated cells) such as blood cells, brain cells, muscle cells, heart cells (cardiomyocytes), etc. It is this ability to change into cells with specific functions capable of replacing ailing or missing cells that underlies the hope they can ultimately be used to cure a vast number of diseases from diabetes to cancer and heart disease.

There are two types of stem cells.

- **Embryonic stem cells** are harvested from embryos that are surplus from in vitro fertilization procedures.
- **Adult stem cells** are undifferentiated, dormant cells found among the usual differentiated cells in tissues and organs that are able to renew themselves. The primary purpose of adult stem cells is to maintain and repair the tissue in which they are found.

Stem cells are classified as pluripotent, multipotent or induced pluripotent.

- **Pluripotent stem cells** can differentiate into any type of cell found in the body except those needed to support and develop a fetus in the womb. Embryonic stem cells are pluripotent.
- **Multipotent stem cells** can only differentiate into a limited number of different cells with specific functions. Some, but by no means all, adult stem cells are multipotent.
- **Induced pluripotent stem cells (iPSCs)** are adult stem cells that have been genetically reprogrammed to behave like an embryonic cell. At present it is not clear if iPSCs are totally equivalent to natural embryonic stem cells.

Finally, stem cells may be allogeneic or autologous.

- **Allogeneic cells** are obtained from usually young, healthy donors, often from bone marrow. These cells have the advantage of being healthy, but carry the risk of being rejected by the recipient's immune system.
- **Autologous cells** are obtained from the intended recipient and reimplanted once they have been "cleaned up" and multiplied by laboratory culture. These cells have the advantage of "being known" to the recipient's immune system but may be because they are usually older, carry genetic faults induced through DNA damage.

Bone marrow is a particularly rich source of stem cells. One type, called a hematopoietic stem cell, is able to develop into many different types of blood cells including platelets and red and white blood cells. It is possible, but still debated, that hematopoietic stem cells can also develop into other cells with heart cells being of particular interest.

Stem cell therapy or regenerative/reparative medicine is a rapidly evolving field. Basically the idea behind it is that by injecting stem cells into diseased organs or tissue the stem cells will differentiate into new, healthy cells with the specific function of the surrounding cells and thus result in repair or rejuvenation of the targeted organ or tissue. The way differentiation of stem cells work is intriguing indeed. Apparently the physical contact between the cells of the targeted organ or tissue and a stem cell sets in motion a complex chain of events that through several cell divisions transforms the stem cell into a cell with the desired specific function.

Considerable advances have been made in the treatment of diabetes via the introduction of stem cells to replace ailing or destroyed beta-cells[1,2]. Two clinical trials, SCIPIO and POSEIDON, recently reported encouraging results from the injection of stem cells into the heart muscle of heart failure patients and heart attack survivors[3,4].

There is also emerging evidence that stem cell therapy may be useful in creating biological pacemakers (replacing implanted ones), repairing malfunctioning AV nodes and eliminating cardiac arrhythmias, such as atrial fibrillation, through biological ablation[5]. British cardiologists recently reported a case where a patient with permanent atrial fibrillation returned to normal sinus rhythm after an injection of hematopoietic stem cells directly into the vein of Marshall[6].

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The AFIB Report is published by Hans R. Larsen MSc ChE
1320 Point Street, Victoria, BC, Canada V8S 1A5
Phone: (250) 384-2524
E-mail: editor@afibbers.org
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