Stem cells and their properties

All multicellular animals and plants rely on stem cells to grow from a single cell into an adult. Stem cells allow our bodies to build new tissue, such as new muscle when we exercise. Stem cells also continually replace the manyspecialised cells in our body if they are worn out or damaged. This allows us to heal broken bones and replace skin damaged by cuts and burns. All of this makes stem cells extremely important in the process of development, cell renewal and healing. Researchers hope that understanding how stem cells work will help to develop new therapies for many different diseases, from cancer to multiple sclerosis.

Stem cells are defined by two key characteristics:

- the ability to continuously divide to generate exact copies of themselves in a process called self-renewal;
- the ability to change into specialised cells in a process called differentiation.

Self-renewal and differentiation might seem like simple concepts, but more research is needed to understand these processes.

Types of stem cells

There are many types of stem cells. Each type plays a different role in the body as we grow and develop. Some stem cells only exist for a limited period, such as during the development of an embryo. Others are only found in specific parts of the body, such as in hair follicles or the liver. Depending on the purpose and location of the stem cells, there may be limitations to what cell types the stem cell can differentiate into. Research has also led to technologies to make different kinds of stem cells in the laboratory. Generally, all stem cells fall into three different groups:

Embryonic stem (ES) cells and epiblast stem cells

Embryonic stem cells are pluripotent cells, which means they can differentiate into all of the types of specialised cells in the body. ES cells are derived from cells found within a 4 to 5 day old embryo called a blastocyst. The blastocyst is a very small ball of about 150 cells with a diameter of ~0.2 mm. A cluster of cells within the blastocyst, called the inner cell mass, contains stem cells that researchers isolate and grow in the laboratory as ES cells.

Epiblast stem cells share several features with embryonic stem cells, including the ability to differentiate into all types of specialised cells, but are derived from later embryos that have implanted into the womb.

Tissue stem cells

Tissue stem cells can both self renew and give rise to at least one more specialised (differentiated) cell type. They can be unipotent, meaning that they only make one type of specialised cell (eg the spermatogonial stem cell) or multipotent, meaning they can generate several types of specialised cell. Under normal circumstances, tissue stem cells generate only the cell types that make up the or organ / tissue system they reside in.

Induced pluripotent stem (iPS) cells

Many years of researchers learning about how stem cells function has led to the development of iPS cells. Researchers discovered that artificially activating specific genes could induce many different cells to become pluripotent, similar to ES cells. iPS cells have attracted a lot of attention because these cells can be generated from adults, avoiding the ethical concerns associated with research using human embryos.

Regenerative medicine research

Research and technological advancements are bringing regenerative medicines closer to reality.

Aging, injuries and diseases are the result of damaged, malfunctioning or dying specialised cells. By better understanding how stem cells are controlled and how diseases develop, researchers hope to find new ways to treat patients. As such, regenerative medicine aims to restore normal function by repairing or replacing damaged or malfunctioning cells and tissues in patients.

Research in regenerative medicine is bringing tremendous advances in science, technology, health and medicine. These advances hold promise for improving methods of disease diagnosis and prevention, to the development of innovative treatments for injuries and illnesses. Research by scientists hinges on learning how different biological processes work and applying that knowledge to:

- better understand the causes and progression of different diseases, such as Parkinson's disease and multiple sclerosis, which facilitates better treatments;
- create new biological tools and technologies to accelerate research, drug discovery and the medical testing while also reducing costs and animal use;
- design and develop novel treatments to both enhance natural repair processes and use the abilities of stem cells for replacing damaged, malfunctioning or diseased cells.

Currently, the only approved medical use of stem cells in the United Kingdom is bone marrow transplants (also called haematopoietic stem cell transplants) for treating blood and disorders in the immune system. Other stem cell treatments being used in the UK, but not yet for general use, include emergency skin grafts using skin (epidermal) stem cells and repairing the cornea of the eye using limbal stem cells. However, many stem cell treatments are being

researched and several show promise in clinical trials (the official medical treatment approval process).

Why are stem cell treatments not widely used yet?

Developing new medical treatments is a long process with many steps to ensure safety and effectiveness. New ideas for treatments must first be developed and rigorously tested in laboratories before being tested on people in clinical trials. The clinical trial approval process has many government rules and regulations to protect patients. If approved in clinical trials, a treatment then needs the pharmaceutical and biotech industries to further develop it for widespread use. Overall, making a new treatment can easily take 15 to 20 years and is very expensive. In fact, most ideas don't ever become approved treatments.

Unapproved stem cell treatments are sometimes offered by unregulated companies and clinics. Unapproved procedures often lack scientific evidence showing they work and may even be dangerous. It is important that patients discuss medical decisions with their general practitioner (GP) before seeking out medical treatments. The International Society for Stem Cell Research has a very informative website and patient handbook, which is an excellent starting point for learning more about stem cell treatments. In addition, the website eurostemcell.org provides the latest accurate information regarding research progress. It is also an exceptional online resource to find out more about stem cells and their potential uses as well as limitations in treating disease.