MND Factsheet 16
Stem Cells

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Introduction

Many people think stem cells have great potential for treating a wide range of disease and disability since they are able to replace cells or structures that have been damaged or lost due to disease.

Why are they so useful?

When a stem cell divides, each new cell has the potential to either remain a stem cell or become another type of cell with a more specialised function. Scientists believe it should be possible to harness this ability to turn stem cells into a super "repair kit" for the body.

Theoretically, it should be possible to use stem cells to generate healthy tissue to replace that either damaged by trauma, or compromised by disease. One day Motor Neurone Disease and other degenerative conditions such as Parkinson's and Alzheimer's may be successfully treated along with other conditions including heart disease, stroke, arthritis, diabetes, burns and spinal cord damage. Stem cells also provide a useful way to test the effects of experimental drugs. Studying stem cells and tissues derived from them in culture is now providing vital clues about how the tissues of the body develop, how diseases can influence cells and possible mechanisms for countering disease processes.

Are there different types of stem cell?

The stem cells found within adult organs have not taken on a final role, and while they have the potential to become any of the major specialised cell types within that organ they cannot make specialised tissues for other organs. Their role is to maintain the organ in a healthy state by repairing any damage it suffers throughout life. It is thought their potential to become other types of cell is more limited than that of stem cells found in the early developing embryo (embryonic stem cells), however, there is evidence that they are still relatively "plastic" and are able to make a limited number of specialised cell types.

Until recently stem cells from embryos (embryonic stem cells) were considered to hold the greatest potential for development as cures for disease because they have the ability to become virtually any type of cell within the body. (Scientists describe these as pluripotent.) However, more recently techniques have been developed which can reset more specialised stem cells to an earlier stage of development and allow them to make the full range of cells found in the body. These are referred to as induced pluripotent stem cells.

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Although stem cell research is laboratory based it is hoped that the knowledge derived from the research can be translated into practical therapies and treatments for use in medicine.

How do existing stem cell treatments for MND work?

No MND patient has yet been known to recover from the disease as a result of commercially available stem cell treatment, although many have paid privately for such treatments.

Why Don't Stem Cell Treatments Work For MND?

Many of the treatments currently offered involve injecting stem cells into the bloodstream and allowing the body to direct their use. Unfortunately this approach is useless for treating neurological conditions like MND as the nerve sheaths and similar structures prevent cells from moving from the blood into the nervous system. In order to repair the damage caused by a disease like MND stem cells need to get into the nervous system itself.

Once inside the nervous system a stem cell would have to both change to a motor neurone and grow along the same route as a dead motor neurone to connect the muscle it served with the very specific part of the brain which controlled that muscle. Within the muscle the new neurone would need to branch and infiltrate the fibres of the muscle to make sure the signals it carries can reach the muscle fibres telling them when to contract.

This all sounds relatively straightforward, until you realise that the length of some motor neurones is over a million times that of their width and some would need to grow over a metre in length to connect a muscle to the spinal cord. Very small repairs of a few millimetres to the nervous system, for example if a nerve is damaged during the extraction of a tooth, can take months to achieve. How long might it take to grow a neurone along the length of the sciatic nerve to connect the spine with a leg muscle?

There are additional problems that may be encountered. Dental patients who have suffered nerve damage during an extraction often report that once they have regained sensation it feels as though the nerves have become "crossed" for example touching a lip may feel to them that it is their chin that has been touched or vice versa. Such a "crossover" would create obvious problems if some of the muscles of, say, the calf connect to part of the brain that controls the thigh, while other calf muscles connect to a part that controls, for example, an arm.

Are there safety concerns?

Yes. There is particular concern that stem cells are currently cultivated using nutrients taken from animal sources, and that these could harbour diseases which could be passed on to humans. Some research has also raised the possibility that stem cells may turn cancerous.

More importantly, however, is the concern that many of the clinics offering stem cell treatments are located in third world countries where this type of medicine is almost entirely unregulated. People purchasing these treatments do not necessarily have the protections they would have if the same treatments were offered in parts of the world with more regulated medical systems.

In addition the stem cells offered by these companies are often taken from the umbilical cords of aborted foetuses, with no guarantees as to the genetic suitability or disease-free status of the source.

It is not known how to control their growth within the nervous system; to encourage normal development and differentiation into motor neurones and prevent the development of cancerous growths. It is not known how to prevent them making “wrong connections” and misconnecting muscles to the wrong parts of the nervous system and it is not known how to encourage them to infiltrate muscle tissue and make the proper connections there.

In time it is hoped these questions will be answered, but until they are anyone paying for stem cell treatments may be exposing themselves to unnecessary financial and health risks.

What hope is there?

Stem cell therapies are undoubtedly at the cutting edge of medicine and will, in the future, be used for exactly the type of medicine a person with MND would want. The challenges faced in their use are simply too great at the moment for them to be used safely and effectively.

Much research activity is currently directed at using stem cells and their derivatives in cultivation to understand what is going wrong in neurological conditions, with considerable effect.

Some Stem Cell Biology

All the cells of the body develop from a fertilised egg which consists at first of a single cell. After fertilisation this single cell divides in a coordinated way to form ever larger numbers of cells. At first it divides to form two cells, then four cells, then eight cells and so on with each division increasing the number of cells within the embryo.

In the very early embryo every cell has the potential to make every type of cell necessary for a fully functioning organism. This is best illustrated in identical twins where, at a very early stage of development, the ball of cells has separated into two distinct groups which go on to give rise to twin individuals with identical genes. Each is a complete and fully functioning individual. However, if this split happens too late in development both halves of the embryo will die due to each half missing essential tissues that should be derived in the other partner.

As cell divisions take place in an early embryo there comes a time when some of the cells begin to become specialised according to their position within the ball of cells. It is thought that this specialisation is brought about by cells in different parts of the ball switching certain genes on or off according to the cell’s relative position within this ball and also according to what the cells round about have done with their genes.

One of the first structures to be seen in a developing embryo is a groove along one part of the ball of cells. It is now known the cells around this groove will ultimately give rise to all the tissues of the nervous system such as the eye, the brain, the spinal cord and the nerves themselves.

Researchers investigating the development of the embryos of animals such as frogs, newts and chickens have used this groove as a marker to help them divide the embryo into different regions.

Observation has shown that each of these regions would naturally give rise to different structures in the mature organism. However, experimentation has shown that when specific groups of cells are removed from one part of the early embryo and transplanted to a different position in the embryo two different results are possible: If the transplant takes place early enough the transplanted cells will develop and become the tissues and structures that should be found in their new position; But when the transplant takes place after a certain point in development has been reached it is possible for these transplanted cells to continue their development as though they had not been moved and produce the structures they should have made if they had not been transplanted. In other words, the type of tissue these transplanted cells should make has already been determined.

These findings have given rise to the theoretical model that all of the possible types of cell could be thought of as a tree with the unspecialised types of cell of the very early embryo represented by the stem of the tree.

The first branches coming from the stem of this tree represent the broad families of tissue types such as nervous tissue in general. Smaller branches arising further up these first branches represent even more specialisation of the nervous tissues until we reach the very tips of the finest branches which represent one specific tissue type.

It is implicit within this theoretical model that cell development proceeds from the unspecialised to the ever more specialised with no possibility of the process going in reverse. Cells represented by the stem of the plant have the potential to give rise to all of the possible cell types, while those cells represented by a branch can only give rise to the cell types derived from that branch.

Until recently the above view was held to be true and, as a result, the only source material of sufficiently large numbers of stem cells for researchers was thought to be those derived from embryos. For this reason stem cell use and stem cell research was spoken against and outlawed by organisations and governments which had moral and ethical objections to research involving human embryos. Recent advances have shown stem cells can be isolated and cultivated from adult tissues and that it is also possible, in the lab, to reverse the development of specialised cell types and then derive different, but related, specialised cell types. One recent report described how the development of cultured skin cells was firstly reversed and then changed to produce nerve cells.

It is hoped that as knowledge of stem cells grows the days when they can be used effectively in treating neurological disorders are coming closer.

Further Reading

Factsheet 28 Complimentary Therapies

Factsheet 26 Current Research

EuroStemCell reliable independent information on stem cells *www.eurostemcell.org*
Their factsheets can be found at *www.eurostemcell.org/stem-cell-factsheets*

BBC Article on Stem Cell Fraud http://news.bbc.co.uk/1/hi/health/4985230.stm
BBC Article on Stem cell therapy disease warning http://news.bbc.co.uk/1/hi/health/4561933.stm