3D printing breakthrough with human embryonic stem cells

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A team of researchers from Scotland has used a novel 3D printing technique to arrange human embryonic stem cells (hESCs) for the very first time.

It is hoped that this breakthrough, which has been published today, 5 February, in the journal *Biofabrication*, will allow three-dimensional tissues and structures to be created using hESCs, which could, amongst other things, speed up and improve the process of drug testing.

In the field of biofabrication, great advances have been made in recent years towards fabricating three-dimensional tissues and organs by combining artificial solid structures and cells; however, in the majority of these studies, animal cells have been used to test the different printing methods which are used to produce the structures.

Co-author of the study, Dr Will Wenmiao Shu, from Heriot-Watt University, said: "To the best of our knowledge, this is the first time that hESCs have been printed. The generation of 3D structures from hESCs will allow us to create more accurate human tissue models which are essential for in vitro drug development and toxicity-testing. Since the majority of drug discovery is targeting human disease, it makes sense to use human tissues."

In the longer term, this new method of printing may also pave the way for incorporating hESCs into artificially created organs and tissues ready for transplantation into patients suffering from a variety of diseases.

In the study, the researchers, from Heriot-Watt University in collaboration with Roslin Cellab, a stem cell technology company, used a valve-based printing technique, which was tailored to account for the sensitive and delicate properties of hESCs.

The hESCs were loaded into two separate reservoirs in the printer and were then deposited onto a plate in a pre-programmed, uniformed pattern.

Once the hESCs were printed, a number of tests were performed to discern how effective the method was. For example, the researchers tested to see if the hESCs remained alive after printing and whether they maintained their ability to differentiate into different types of cells. They also examined the concentration, characterisation and distribution of the printed hESCs to assess the accuracy of the valve-based method.

Dr Shu said: "Using this valve-based method, the printed cells are driven by pneumatic pressure and controlled by the opening and closing of a microvalve. The amount of cells dispensed can be precisely controlled by changing the nozzle diameter, the inlet air pressure or the opening time of the valve.

"We found that the valve-based printing is gentle enough to maintain high stem cell viability, accurate enough to produce spheroids of uniform size, and, most importantly, the printed hESCs maintained their pluripotency – the ability to be differentiated into any other cell type."

Roslin Cellab has a track record of applying new technologies to human stem cell systems and will take the lead in developing 3D stem cell printing for commercial uses.

Jason King, business development manager of Roslin Cellab, said: "This world-first printing of human embryonic stem cell cultures is a

continuation of our productive partnership with Heriot-Watt. Normally laboratory grown cells grow in 2D but some cell types have been printed in 3D. However, up to now, human stem cell cultures have been too sensitive to manipulate in this way.

"This is a scientific development which we hope and believe will have immensely valuable long-term implications for reliable, animal-free drug-testing and, in the longer term, to provide organs for transplant on demand, without the need for donation and without the problems of immune suppression and potential organ rejection."

hESCs have received much attention in the field of regenerative medicine. They are originally derived from an early stage embryo to create "stem cell lines" which can be grown indefinitely and differentiate into any cell type in the human body.

"In the longer term, we envisage the technology being further developed to create viable 3D organs for medical implantation from a patient's own cells, eliminating the need for organ donation, immune suppression and the problem of transplant rejection," continued Dr Shu.

More information: "Development of a valve-based cell printer for the formation of human embryonic stem cell spheroid aggregates" Faulkner-Jones et al 2013 Biofabrication 5 015013 . iopscience.iop.org/1758-5090/5/1/015013

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